# DEPARTMENT OF EDUCATION

# PROVINCE OF ALBERTA

# RESEARCH PROJECT ON SCHOOL CONSTRUCTION

# REPORT

REID, CROWTHER & PARTNERS LIMITED

LALONDE, VALOIS, LAMARRE, VALOIS & ASSOCIES

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November 10, 1969

Department of Education,
Government of the Province of Alberta,
Room 628, Administration Building,
Edmonton, Alberta

Gentlemen:

Re: School Costs Study

It is with pleasure we submit our report covering the results of our study of school construction costs in the Province of Alberta.

The study comprised an in depth analysis of the achievements of the various school authorities, designers and builders in the Province of Alberta for the period 1966 to 1968 inclusive.

This review indicated that successful schools were being built for costs well below $16.00 per square foot.

Upon analysis and establishment of a normalized unit cost per square foot based on the standards, we found gaining most general acceptance in the Province, the following costs per square foot were found to be reasonable:

2......

Reid, Crowther & Partners Limited
Lalonde, Valois, Lamarre, Valois & Associés
[illegible]
[illegible]

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[illegible]
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Edmonton, Alberta

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| | |
|---|---|
| Elementary Schools<br>Non Air Conditioned | \$15.05 per sq.ft. of gross floor area |
| Junior High Schools<br>Air Conditioned | \$15.25 per sq.ft. of gross floor area |
| Senior High School<br>Air Conditioned | \$15.10 per sq.ft. of gross floor area |

These costs represent the school plant construction cost only, not adjusted for architects and consultants fees, nor sales tax credits. When allowance is made for these items the gross cost is increased by approximately 25¢ per square foot.

We wish to express our pleasure at the opportunity to serve the Department of Education in the study and thank the members of the Department for their cooperation in facilitating the progress of this study.

Yours truly,

REID, CROWTHER & PARTNERS LIMITED
LALONDE, VALOIS, LAMARRE, VALOIS
& ASSOCIES

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DEPARTMENT OF EDUCATION

PROVINCE OF ALBERTA

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# PART I -- INTRODUCTION

## 1.1 PURPOSES AND SCOPE OF STUDY

During recent years the Department of Education has experienced a wide variety of styles in school design as well as a wide range of unit costs.

It was considered desirable by a number of professional groups concerned with school design that an in depth review be carried out to assess the various practices in effect today, with a view to bringing about some rationalization of these practices with the hope that a greater consistancy of design and costs would be achieved.

Early in 1969, the Department of Education, in consultation with a number of groups expressing interest in this type of review, undertook to have a study carried out. Terms of reference were established in keeping with the various representations made and a study was commissioned to carry out an initial survey of the physical school plant currently in use. This study was limited to a review of new schools recently constructed in the province. Simultaneously, a study was commissioned to carry out a functional review of the facilities

1.1 PURPOSES AND SCOPE OF STUDY (cont'd)

currently being adopted from the point of view of pedagogical requirements. Munzel & Associates, Architects, were retained as consultant architects by the study group for the review of the schools.

This report deals with the findings related to the physical plant as required under the terms of reference. The study was not extended to matters relating to additions and renovations.

1.2 METHOD OF STUDY

It was determined, in keeping with the wide variety of school locations and functional types of schools, that as large a cross section of schools should be selected as practical. The schools reviewed should also be representative of current practices and current cost history.

It was also determined, as part of the philosophy of the study, that it was not the intention to establish a stereotyped school but to arrive at a functional school which, in utilizing the various systems available, would allow as much room for originality and expression as was practical within the limits of reasonable cost.

It must also be understood that level of service, aesthetics and quality of finish are all to some degree subjective decisions. Part of the analysis was therefore to attempt to establish the apparent net benefits various approaches achieved.

1.2 METHOD OF STUDY (cont'd)

Included in this analysis would be the apparent results of any increased expenditure on school plant versus the possible loss of quality in the lower cost schools. As a result of the analysis it was hoped there would be some cost benefit rationale established in regard to the various approaches assessed. These would be considered both from the point of view of physical plant and functional performance.

The above fundamental parameters having been established for the study, forty two schools were selected in conjunction with the Department of Education and the School Boards for review. These schools were representative of both the urban and rural schools as well as providing a reasonable cross section of elementary, junior and senior high schools.

The schools selected also covered the cost spectrum of schools designed and constructed during the period selected for study. Schools were found to vary in cost from approximately $13.80 per square foot to $21.00 per square foot. The period selected for review, with the odd exception, represented schools construction during the years 1966, 1967 and 1968 (see Table I, Page 9).

Cost information was gathered for these schools in respect to architectural, electrical, mechanical and structural elements. These cost breakdowns were tabulated for the schools individually and the schools were reviewed on this basis in conjunction with the various systems used and the apparent functional

1.2 METHOD OF STUDY (cont'd)

efficiency of the schools.

From this review it was quickly determined that the number of schools to be studied in more detail could be materially reduced, insofar as a number of schools were basically similar. As a result, a smaller number of schools could be reviewed in much greater detail. The schools selected would still be representative of the various design philosophies used.

1.2.1 In Depth Study of Schools

In order to facilitate comparison between schools, each building studied was subdivided into a number of specific components as listed in Appendix "A".

Other items such as:

a) Special Conditions,

b) Integrated equipment,

c) Site improvement,

d) Contingencies,

which may vary considerably from one school to the other were studied and reported separately.

1.2.2 Construction Budgets

Budget figures were established from the adjusted costs for each item. The figures adopted represent the cost experienced in practice

1.2 METHOD OF STUDY (cont'd)

in developing a suitable school plant by the various design authorities and are adjusted to reflect the upper limit related to the norm school. The figures indicated for the various items making up the budget are interdependent and may vary with individual projects so long as the total remains the same.

1.2.3 Sources of Information

To establish as accurately as possible the cost of the various elements of school buildings under study, the research team used three main sources of information. These were:

a) Plans, specifications and construction files supplied by the Department of Education,

b) Cost information supplied by the School Boards,

c) Cost information supplied by general contractors and subcontractors.

The information thus obtained was supplemented, whenever necessary, by detailed cost estimates made by the research team members.

1.2.4 Conclusions

As a result of the analysis carried out and the visits of the school plant, it became readily evident to the study group that a number of designers were successfully designing schools which were on the

1.2 METHOD OF STUDY (cont'd)

low side of the cost scale and at the same time proving quite satisfactory from the functional and aesthetic aspects as well as the maintenance operation, and pedagogical considerations.

These schools had many features which were excellently conceived, both from the functional design aspects and the utilization of materials and systems insofar as the building was concerned.

In general it was found that these schools were compact in design, window areas were kept to a minimum, materials were selected carefully and utilized well, systems were well conceived and designed, and layouts were efficient and functional.

From the analysis of the schools in question a budget has been prepared for the construction of elementary, junior high and senior high schools. These budgets are based on the cost experience for the years 1966, 1967 and 1968.

These budgets represent a combination of the better systems and materials utilized in the designs, with allowance for contingencies and certain variances in the bidding climate as well as permitting a degree of flexibility in design expression.

The resultant budget figures are:

Elementary schools $15.05/sq. ft.

1.2 METHOD OF STUDY (cont'd)

| | |
|---|---|
| Junior High Schools | \$15.25/sq. ft. |
| Senior High Schools | \$15.10/sq. ft. |

The above budget figures would not, of course, cover schools in extremely remote or isolated areas not reviewed in the study. These figures represent the building costs only and do not include architect's fees or sales tax credits. To allow for architects' fees and sales tax credits add 25¢ per square foot to the above unit costs.

Junior and Senior High Schools include an allowance for air conditioning.

The study and conclusions are described in detail in the following text of the report. Appended to the report are the comments of the Human Resources Research Council.

1.3 DEFINITION

In this report the term square foot, unless mentioned otherwise, means the gross square footage of floor area of building.

1.4 CONSULTATIONS

During the course of the Study, meetings were organized by the Department of Education on behalf of the study team, with the representatives of various associations and committees.

The purpose of these meetings was, to explain in detail to all those

## 1.4 CONSULTATIONS

connected with school construction the scope and objectives of the Study, to obtain cooperation and to gather information, comments and recommendations relevant to the scope of the Study.

The various associations and committees who participated in such meetings are the following:

i) Advisory Committee on School Buildings,

ii) Educational Facilities Council,

iii) Alberta Association of Architects,

iv) Association of Professional Engineers of Alberta,

v) Alberta Construction Association.

## 1.5 ACKNOWLEDGEMENT

The research team has experienced excellent cooperation with the various parties who were in a position to supply the necessary information in order to make a success of this Study.

The Consultants want particularly to express their gratitude to:

- Dr. L. G. Hall and the personnel of the Department of Education.
- The various School Boards who supplied information and helped in the visits of the schools studied.
- Contractors who supplied cost information required.

## TABLE I

## LIST OF SCHOOLS

| Case No. | Size of School | Date of Tender | Cost/Sq.Ft. |
|---|---|---|---|
| 1E (1) | 40,000 (2) | February 1966 | 16.50 (3) |
| 2E | 44,000 | February 1967 | 19.41 |
| 3E | 32,000 | September 1967 | 13.58 |
| 4E | 33,000 | September 1967 | 15.90 |
| 5E | 42,000 | November 1967 | 13.63 |
| 6E | 32,000 | August 1968 | 13.76 |
| 7E | 20,000 | June 1967 | 14.92 |
| 8E | 20,000 | November 1967 | 15.52 |
| 9E | 42,000 | November 1967 | 16.04 |
| 10E | 30,000 | December 1967 | 18.32 |
| 11E | 45,000 | January 1968 | 18.64 |
| 12E | 20,000 | April 1968 | 13.76 |
| 13E | 25,000 | September 1967 | 16.09 |
| 14E | 30,000 | February 1967 | 17.82 |
| 15E | 35,000 | April 1967 | 17.92 |
| 16E | 30,000 | June 1968 | 16.37 |
| 18E | 25,000 | March 1967 | 18.77 |
| 19E | 40,000 | December 1968 | 12.72 |

TABLE I (continued)

| Case No. | Size of School | Date of Tender | Cost/Sq. Ft. |
|---|---|---|---|
| 20E | 25,000 | September 1965 | 20.79 |
| 21E | 25,000 | March 1969 | 16.00 |
| 1J | 75,000 | October 1967 | 13.38 |
| 2J | 70,000 | November 1967 | 13.43 |
| 3J | 60,000 | October 1966 | 17.87 |
| 4J | 40,000 | September 1967 | 16.83 |
| 5J | 60,000 | October 1967 | 16.69 |
| 7J | 50,000 | May 1967 | 16.98 |
| 8J | 75,000 | October 1966 | 16.31 |
| 9J | 55,000 | October 1966 | 19.06 |
| 10J | 40,000 | January 1967 | 17.95 |
| 11J | 40,000 | March 1968 | 14.85 |
| 12J | 50,000 | April 1968 | 18.26 |
| 13J | 40,000 | January 1966 | 15.25 |
| 14J | 40,000 | Auguat 1966 | 18.02 |
| 1S | 200,000 | April 1965 | 16.17 |
| 2S | 270,000 | June 1968 | 16.25 |
| 3S | 290,000 | March 1966 | 18.51 |

TABLE I (continued)

| Case No. | Size of School | Date of Tender | Cost/Sq. Ft. |
|---|---|---|---|
| 4S | 200,000 | October 1967 | 20.98 |
| 5S | 200,000 | April 1969 | 17.62 |
| 6S | 75,000 | February 1967 | 19.65 |
| 7S | 55,000 | November 1967 | 19.28 |
| 8S | 45,000 | November 1967 | 18.25 |
| 9S | 85,000 | January 1967 | 19.95 |

NOTES:

(1) The letter after the number means:

E: Elementary School

J: Junior High School

S: Senior High School

(2) The size of the school is given in approximate number of square feet of gross floor area.

(3) The cost is given per square foot of gross floor area and includes the architect's fees and integrated equipment and excludes the federal sales tax and costs of site development.

## PART II - ANALYSIS OF CASE HISTORIES

This section summarizes the results of the analysis of the schools selected. These results are tabulated and reviewed in accordance with the major subtrades. All unit prices given in this section, unless mentioned otherwise, are in terms of gross square feet of floor area.

### 2.1 ARCHITECTURAL

#### 2.1.1 Selection of Schools

For the in depth study of the architectural components of school buildings, 10 were chosen as most representative of all the schools submitted for study. Six were elementary schools varying in size from 20,000 square feet to 42,000 square feet, two were junior high schools of 40,000 square feet and 70,000 square feet and 2 were senior high schools of 75,000 square feet and 270,000 square feet.

Seven elementary and junior high schools were one story buildings and one had two stories. One senior high school had one story and the other had two stories.

#### 2.1.2 Norm School

After studying the plans and specifications of all of the schools submitted and after visiting the majority of them, the study group arrived at some basic standards that seemed to have been adopted by most School

2.1 ARCHITECTURAL - Norm School (con't)

Boards and were found to perform satisfactorily. These standards can be summarized as follows:

2.1.2.1 Roofing

-4 ply B.U.R. conforming to the Alberta Roofing Contractors Association Ltd. specifications.

- U factor including all components of the roof equal to 0.15 BTU/hr/sq.ft.

2.1.2.2 Exterior Walls

- U factor of walls except for window area: 0.12 BTU/hr/sq.ft.
- Maximum infiltration through walls: 0.1 cu ft/hr/sq/ft/
- Exterior surface: clay brick veneer, stucco or concrete blocks.
- windows restricted 10% to 20% of wall area.
- Double glazed and/or double sash windows with thermo break (63-GP-2)

2.1.2.3. Interior Partitions

- Min: 45 decibels sound absorption rating
- Gypsum board on steel studs or,
- 6" concrete blocks non bearing or,
- 8" concrete blocks bearing walls.

2.1 ARCHITECTURAL - Norm School (cont'd)

-Folding partions where need dictated by teaching requirements.

- Solid core wooden doors.

-Metal door frames

- Epoxy or ceramic tiles on washroom walls.

- Steel toilet partitions.

2.1.2.4. Ceilings

- Gypsum board or acoustic tiles on metal suspension or spray applied directly on structural slabs in academic, administration and other similar areas.

- Exposed structural members painted in shop areas and gymnasiums.

- Exposed painted structural members in mechanical rooms, janitor closets, etc.

2.1.2.5. Flooring

- Vinyl asbestos tile 1/8" x 12" x 12" (Academic, Administration cafeteria areas and corridors).

- Carpeting (Library and academic areas in group teaching schools).

- Hardwood 25/32" T & G maple on sleepers and rubber cushions (Gymnasium).

2.1 ARCHITECTURAL - Norm School (cont'd)

- ceramic tile or seamless plastic covering (sanitary areas)
- Exposed concrete treated with cement hardener (shop, mechanical room, storage areas, etc.).

2.1.2.6 Painting

| | |
|---|---|
| - Woodwork: | |
| Natural finish | 1 coat primer<br>2 coats of urethane |
| Paint finish | 1 coat of primer<br>2 coats of enamel |
| Rough sawn finish | 1 coat of resin<br>base stain |
| - Concrete blocks | 1 coat of primer<br>2 coats of alkyd enamel |
| - Plaster surfaces | |
| Walls | 1 coat primer<br>2 coats of alkyd enamel |
| Ceilings | 1 coat primer<br>2 coats of latex paint or alkyd enamel |
| - Conrete floors | 1 coat of floor urethane enamel |
| - Wood floors | 1 coat of primer<br>3 coats of urethane varnish |

2.1 ARCHITECTURAL (cont'd)

2.1.3 Unit Costs

In order to establish a budget for the architectural components of a school building, we have analyzed each item as listed in Appendix "A" to arrive at a unit cost per square foot.

2.1.3.1 Roofing

The unit costs of roofing varied little for schools of comparable sizes. The unit prices have shown a definite tendency to decrease as the size of the building increases. For roofing of the standards as outlined in section 2.1.2.1, we have arrived at the following unit prices per square foot of gross floor area.

$.50 for elementary and junior high schools, one story and less than 50,000 square feet.

$0.35 for elementary and junior high schools, two story and less than 50,000 square feet.

$0.45 for junior high schools, one story and more than 50,000 square feet.

$0.35 for senior high schools, two story and more than 150,000 square feet.

2.1.3.2 Exterior Walls

The total cost of exterior walls is influenced by two main factors:

2.1 ARCHITECTURAL-Unit Costs (cont'd)

a) the composition of the walls,

b) the ratio of exterior walls to floor area.

A wall made according to the norms outlined in section 2.1.2.2 can be built for $3.15 per square foot of wall including windows and doors. In the analysis, it was found that the ratio of exterior wall area to the gross floor area varied from 30 to 60% depending on the type of school.

The unit costs based on the average ratios of the area of wall to the area of floor for the different types are as follows:

$1.25 for elementary and junior high schools, one story and smaller than 50,000 square feet, using a ratio of 40% (3.15 x 0.40 =$1.25).

$1.42 for elementary and junior high schools, two story and smaller than 50,000 square feet, using a ratio of 45% (3.15 x 0.45 = $1.42)

$1.10 for junior and senior high schools, one story and between 50,000 and 150,000 square feet, using a ratio of 35% (3.15 x 0.35 = $1.10)

$0.90 for senior high schools, two story and more, and greater than 150,000 square feet using a ratio of 30% (3.15 x 0.30 = $0.90).

2.1 ARCHITECTURAL- Unit Costs (cont'd)

2.1.3.3 Interior Partitions

The cost of interior partitions is influenced by the factors similar to that of exterior walls. These factors being:

a) the composition of the partitions,

b) the ratio of partition area to the floor area.

For partitions constructed as per the standards of Section 2.1.2.3, the unit cost was found to vary from $0.95 to $1.20 per square foot of partition. This price takes into account the use of load bearing walls when applicable, corrected to apportion part of its cost to the structure (50%) and also some mobile partitions, etc. To allow for maximum flexibility in design we have adopted the sum of $1.20 as the unit budget price.

The ratio of interior partition area to gross floor area was found to vary from 96% to 109% depending on the type of schools. These percentages have been adjusted for schools where some partitions have been eliminated because of the group teaching methods adopted. In those cases we have added the missing partitions to arrive at the percentage.

We have therefore fixed the budget unit costs per square foot for this item as follows:

$1.30 for elementary and junior high schools below 50,000 square feet using a ratio of 109% (1.20 x 1.09 =$1.30).

$1.20 for junior and senior high schools, between 50,000 and 150,000 square feet, using a ratio of 100% (1.20 x 1.00 = $1.20).

$1.15 for senior high school above 150,000 square feet using a ratio of 96% (1.20 x 0.96 = $1.15).

2.1.3.4 Ceilings

The ratio of finished ceiling area to gross floor area was found to vary from 60% to 95% of gross floor area.

The higher ratio applies to the elementary schools while the lower ratio is for senior high schools. This variation is due to the different types of rooms found in the various schools as outlined in Section 2.1.2.4.

As for partitions, it was found that the unit cost of finished ceiling varied slightly with the quantity. Even in a number of schools where untreated structural slabs were used and where normally finished ceiling is installed, the budget was based on the assumption that all these rooms have suspended

gypsum board or acoustic tile ceilings.

The budget then becomes:

$0.50 for elementary and junior high schools below 50,000 square feet.

$0.45 for junior and senior high schools between 50,000 and 150,000 square feet.

$0.35 for senior high schools above 150,000 square feet.

2.1.3.5 Flooring

The main factor affecting the unit cost of flooring is the proportion of the various qualities of floor covering utilized, and to a lesser degree, the quantity used.

For the schools without vocational shops the proportion of the different qualities of floor covering are generally as follows:

- 50 to 60% vinyl asbestos tiles
- 20 to 30% carpet
- 10% hardwood
- 10% ceramic tiles, quarry tiles, seamless or exposed concrete.

In schools with vocational shops the percentage of less

expensive floor covering increases.

Since all the schools studied had generally satisfactory floor covering, we have established the following budgets by taking the average cost of the schools studied. The average unit costs ranged from \$0.40 to \$0.89 per square foot. Depending on the proportion of carpeted areas, the cost per square foot of gross floor area will, of course, vary considerably. The following budget figures reflect a reasonable allowance to provide the ratios of the various floor covering generally experienced:

\$0.70 for elementary schools

\$0.65 for junior high schools

\$0.55 for senior high schools

2.1.3.6 Painting

Except in certain architectural designs where walls and partitions are made of exposed cast-in-place concrete or blocks, most of the walls and partitions were painted. The cost of painting varied little and the observed average unit cost was \$0.30 per square foot. This figure has been adopted for the budget. Consideration should be given to utilization of plastic wall coatings in view of their very slight increase in unit cost and the relatively lower maintenance cost.

2.1.3.7 Hardware

The observed average unit cost for supply of hardware was

2.1 ARCHITECTURAL-Unit Costs (cont'd)

$0.25 per square foot for elementary and junior high schools and $0.20 per square foot for senior high schools.

2.1.4 Summary of Unit Costs

A summary of the unit costs established in section 2.1.3 gives the detailed budgets as shown in Table 2.

TABLE 2

ARCHITECTURAL COSTS

| | Elementary & Junior up to 50,000 sq. ft. 1 story | Junior & Senior 50,000 to 150,000 sq. ft. 1 story | Senior 15,000 sq. ft. and up 2 stories or more |
|---|---|---|---|
| | UNIT PRICE/SQ. FT. OF GROSS AREA | | |
| 1. Roofing | $0.50 | $0.45 | $0.35 |
| 2. Exterior walls | 1.25 | 1.10 | .90 |
| 3. Interior partitions | 1.30 | 1.20 | 1.15 |
| 4. Ceilings | 0.50 | 0.45 | 0.35 |
| 5. Floorings | 0.70 | 0.65 | 0.55 |
| 6. Painting | 0.30 | 0.30 | 0.30 |
| 7. Hardware | 0.25 | 0.25 | 0.20 |
| TOTAL | $4.80 | $4.40 | $3.80 |

2.1 ARCHITECTURAL (cont'd)

2.1.5 Comments and Recommendations

This part of the report has dealt with the cost aspect of the architectural elements of the school plant. For each element a cost was established based on the norm school in order to arrive at an overall budget figure. These cost figures, as mentioned previously, represent costing experience in schools constructed in the province during the study period.

However, it is fully realized that different design concepts equally as valuable or better would require a different distribution of the cost elements. This budget is not meant to curtail the creative work of the designer but rather to indicate a gross budget level the designer can maintain.

In Part III, the influence of the architectural and engineering details and materials are discussed with their bearing on the overall cost of the schools together with outside cost influencing factors. In this section the architectural concept aspect will be discussed in broader terms. The study of plans and specifications, the visits of the schools, the comments from the administrative and teaching staff and the observations and comments contained in the report from the research team of the Human Resources Research Council (see Appendix "B") point out

practices to be recommended as well as some to be avoided.

2.1.5.1 Layout

The layout of a school is of prime importance both from the standpoint of teaching and administration as well as of cost.

The Human Resources Research Council report has also commented on this respect in Page 9 under the heading "Spacial Pattern": "The philosophy of comprehensive secondary education implies broad programs and large enrolments to justify them. As pupil enrolments rise to the two thousand figure two major problems develop: those of identity and integration. There is the ever-present danger in large schools that individual pupils and teachers, and even classes and departments may lose their identity. At the same time there is the problem of integrating the varied activities, courses and programs in such a way as to produce a unified whole which can be called a secondary school. School design can help to alleviate these problems if spacial planning takes them into consideration".

This statement indicates clearly the need for the establishment of guide lines for the planning of schools where the relationship of the various sectors would be indicated. It was found

that the more compact a school is, normally, the easier it is for its pedagogical administration. Also it was found that compactness offers considerable advantage insofar as it reduces both the cost of construction and of operation.

Some of the main initial cost advantages of compactness are the following:

- It reduces the proportion of exterior walls in relation to the floor area. It was found, for instance, that some schools had twice as much exterior walls as others in proportion of their floor area (30% in some cases to 60% in others), increasing the cost without adding any convenience to the schools.
- With the reduction of exterior walls goes an equal reduction of foundation wall, footings, piling, excavation, etc.
- The structural system is simplified.
- The mechanical system costs are considerably reduced, so much so, that often air conditioning can be included at no extra cost in comparison to installations in rambling school buildings.
- The plumbing installation cost is generally appreciably reduced because of shorter drainage, water supply and return lines.

2.1 <u>ARCHITECTURAL-Comments and Recommendations</u> (cont'd)

-The electrical distribution systems are shorter.

It should also be noted that compactness should be utilized on both the horizontal and vertical plans.

In larger schools the administrators generally preferred a multi-story building rather than the one floor plan. It offers the appreciated advantage of shorter communication distance. The Human Resources Research Council Report recommends that such schools be equipped with small elevators to facilitate the transportation of supplies from floor to floor and also serve for the handicapped students or staff.

The construction savings in multi-story buildings were not found to stem from savings of exterior walls or structural elements but rather in items such as roofing, heating, ventilation and electrical installations. Another advantage which should not be overlooked in the case of a multi-story building is the more efficient use of land.

Though multi-story buildings are practical for larger schools it was found that unnecessary elevation changes on the same floor caused extra expenses and proved to be a handicap for the good

operation of a school.

The Human Resources Research Council Report states in Page 4(Appendix "B"): "....such split levels create problems not only in the flow of pupils but also in the movement of equipment from one part of the school to another".

From the operational point of view a compact building offers the advantage of less heat losses during the heating season and smaller cooling loads in warm weather.

Attention should be given while planning a school to:

-the easy accessibility from the outside to points where delivery of goods is needed,

-the possibility of future extension,

-the utilization of school buildings by the general public as advised in the Human Resources Research Council Report.

A comment frequently heard from school administrators is that entrance vestibules are often too small and that the practice of having a set of doors at each end of the vestibules only creates a bottleneck without helping to break the cold draft in winter, since normally both sets of doors are open at the same time when children enter or leave the school.

Comments were also voiced regarding a general inadequacy of storage space.

These remarks and observations concerning the layout and planning of facilities contained in this report and that of the Human Resources Research Council Report lead to the conclusion that there would be a great deal of advantage in complementing the list of the space allocations in schools as per the Regulations Pursuant to the School Buildings Act, Alberta Regulations No. 199/68 to cover a larger number of the rooms and spaces required in different types of schools. This would apply mainly to the non-instructional areas. It would eliminate many established defects that plague some of the schools and would be an effective way to promote a more efficient use of the floor space. It is, therefore, recommended this situation receive some further attention.

#### 2.1.5.2 Aesthetics

The study group did not observe any price range where schools were more aesthetically pleasing than another. The Report of the Human Resources Research Council mentions in Page 2, "Schools at the high and low ends of the cost scale were paired

for comparative purposes. An attempt was made to arrive at some subjective estimate of the significance of cost in terms of the functionality of the school plant. In general, it may be stated that cost did not appear to be the most significant factor. In some instances the more aesthetically pleasing buildings were somewhat higher in cost than those with lesser aesthetic appeal. In other instances, higher cost interior finishes were actually disfunctional in terms of the needs of students and teachers".

Further on Page 3 the same report comments on the subject of aesthetics in elementary schools: "Given that one of the educational objectives of the elementary school is to develop the aesthestic capacities of the students, some attention must be paid to the aesthetic qualities of the environment within which their learning takes place. What is considered as aesthetic from an architectural point of view, and what is aesthetic from the standpoint of an elementary pupil, however, may not be necessarily one and the same thing. For example, a textured concrete wall may be considered aesthetic by an architect, whereas a wall covered with the children's own creative work may be considered much more aesthetic from an education point of view.

Interior finishes which provide suitable backgrounds for well planned displays of the children's work would appear to be more aesthetically desirable in elementary schools than textured concrete or brick and stone finishes which do not permit such displays.

The criteria for determining the aesthetic features of elementary schools should include, (i) the quality of their appeal to children of elementary age, (ii) the extent to which they contribute to a stimulating learning environment".

The practices to be avoided or those to be incorporated in schools as per the report of the research group of the Human Resources Research Council, either reduces the cost of construction in the first instance or does not add to any significant degree the cost in the second instance.

The pleasant and warm atmosphere in a school, in most cases does not require extra expenditure of money. It was found that the color scheme, the pattern given to concrete blocks and many other such details will do a great deal toward the creation of a pleasant environment.

2.1.5.3. Miscellaneous Items

The following is a list of items which is by no means

exhaustive but points out some of the details observed and found to be worth of mention.

Interior Walls

When concrete blocks are used, it is recommended that a modular design be used as to avoid their cutting. This practice would reduce both the cost of labour and materials and improve the appearance of the walls.

If the partitions are constructed of metal studs and gypsum board, it is recommended that in elementary schools one wall be vinyl coated so as to serve from floor to ceiling as a tack board.

Folding doors and movable walls are costly and delicate pieces of equipment requiring fine adjustment. Their utility though appreciated in certain schools was questionable in others. It is recommended that they be used with caution.

Ceilings

Plaster suspended ceilings were found to be easily damaged when within easy reach and not easily repaired properly. In certain areas it also restricts accessibility to mechanical equipment and electrical installations located in this ceiling space.

In gymnasiums suspended ceilings did not prove successful. They did not correct acoustic problems and were subject to damage by sport equipment.

Floors

Seamless floor covering has in some cases produced unsatisfactory results especially in the cases where it was applied to slabs on grade. Penetration of moisture and alkali caused scaling and discoloration. Also physical education teachers have raised objections to the use of parquet flooring applied directly to concrete slabs in gymnasiums. It lacks the resilience needed for such use.

For stages, soft wood flooring should be used.

Roofing

A large percentage of the schools visited experience leaky roofs. The standards recommended by the Alberta Roofers Association should be adhered to strictly in order to avoid this problem. Care should be taken to slope roofs to obtain positive drainage. For many of the schools visited such was not the case.

Entrances

The visits of the schools have revealed that glass entrance doors and side lights were a source of high maintenance because

of frequent breakage of glass due to accidents or vandalism. In some cases the glass had been replaced with plywood panels.

Skydomes

Skydomes in most instances presented problems of condensation and did not seem to replace artificial lighting. In view of the costs connected with this type of installation, we recommend that their use be avoided.

Windows

The absence of windows or a minimum area thereof brought no unfavourable comments from the users of the schools. It seems to offer many advantages such as comfort because of the reduction in solar gains, and therefore saving in the mechanical installation, a more uniform lighting intensity, reauction in maintenance of windows, drapes or blinds, reduction in the overall cost of exterior walls.

Acoustics

Many school principals were unhappy about the acoustics of certain rooms and of the gymnasiums in particular. This problem could be the subject of further study.

2.1 <u>ARCHITECTURAL-Comments and Recommendations</u> (cont'd)

<u>Color Scheme and Painting</u>

Because of its influence on the level of intensity of lighting, it is recommended that attention be paid to selection of light colors for ceilings and floors and for most walls.

It is also recommended that the use of latex paint be avoided in all areas used by the students because of the difficulty in cleaning such surfaces.

<u>Humidification</u>

Most mechanical installations in new schools included humidification systems which are not found in older schools.

Because of the severe winter conditions found in most parts of the province, the humidification capacity of new building systems presents a potential danger of damage due to condensation. Special attention should be paid by designers to eliminate all possible thermal bridges in their detailing, and ensure the installation of sufficient insulation and vapor barrier materials to all surfaces exposed to the cold elements.

<u>General</u>

The above partial list of details for which comments were received from school users or observed by the study group points

2.1 ARCHITECTURAL-Comments and Recommendations (cont'd)

out the fact that school plants are specialized buildings with specific needs which are not necessarily applicable to other types of buildings. Most practices recommended above would improve school buildings. It was noted that if the items or practices recommended above are not included at the time of design of the school plant, it often becomes impossible to incorporate them in the building after it is built.

There would, therefore, be much advantage in reviewing and complementing the present Alberta School Construction Handbook with a view to updating the handbook and redefining the basic standards currently in use. It is recommended that these guidelines should not restrict further development of new concepts and construction methods which are continually improving the quality and performance of buildings. At the same time deviation from the basic standards established should not occur without a sound basic reason for change.

## 2.2 STRUCTURAL

### 2.2.1 Selection of Schools

Due to the interdependence of the two disciplines, the schools chosen for the structural in-depth study were the same as those for the architectural study. Two special cases were studied where the structural costs represented a higher than normal percentage of the total cost of the building.

### 2.2.2 Division of Elements

For each school studied, the analysis was divided into two main parts, the foundations and the superstructure. The foundations included the building excavation and backfill, strip and isolated footings, foundation walls and pedestals, waterproofing, slabs on grade and special foundation conditions. Special foundation conditions included piling, and extending foundations to a bearing stratum below frost depth. The superstructure included all concrete cast above grade, precast concrete, precast architectural concrete used structurally, load bearing masonry, all structural steel, sawn timber, glued laminated timber and hybrid wood-steel trusses.

### 2.2.3 Design Criteria

The National Building Code of Canada (1965) has been the basis of the design and specification requirements for the schools analysed.

## 2.2 STRUCTURAL (cont'd)

### 2.2.4 Norm School

The structures for elementary and junior high schools were similar in all examples studied. They were generally single story slab on grade buildings, while the high schools were multi-story concrete structures. The following standards represent the average structure based on good design practice as represented in the schools analysed.

#### 2.2.4.1 Foundations

Generally the foundations for elementary, junior and senior high schools were limited to two types:

a) foundation walls with strip footings and isolated footings down to frost free depths,

b) pile foundations with grade beams with maximum pile length in the order of 25 feet. Overall foundation costs using uncased cast-in-place drilled piles to this depth with shallow grade beams were comparable with the normal foundations as described in (a) above.

#### 2.2.4.2 Superstructure

For single story, elementary and junior high schools the superstructure comprised load bearing masonry walls with steel joists, hybrid wood-steel trusses, and glued laminated beams

2.2 STRUCTURAL-Norm School (cont'd)

spanning the range from 28 to 32 feet. Decking consisted of plywood, tongue and groove planking, or light gauge steel. In open areas beams and columns replaced the load bearing masonry. Similar roof structures were used in gymnasiums, however, precast concrete appeared competitive in this span range. Structures not relying on load bearing masonry, where such masonry walls formed the permanent outline of the building, reflected a higher overall cost for the building. In the 28 to 32 foot span range, precast concrete was not competitive.

There were insufficient multi-story elementary and junior high schools for comparative cost study, however, when comparing these schools to the single story structures a reduction in the unit foundation cost offset the increase in the cost of the superstructure.

For senior high schools, the superstructure was generally multi-story cast-in-place reinforced concrete. The school appeared to have a slightly higher unit cost due to the inherent functional design.

Generally the ground floor for all schools was a slab on grade (no crawl space or basement).

2.2 STRUCTURAL (Cont'd)

2.2.5 Unit Costs

A summary of the cost analysis for the schools selected for the in depth study is given in Table 4. (p. 111)

The range of cost for elementary, junior and senior high school structures fell approximately within the same limits.

The average actual cost per square foot in Column 13, Table 4 (p.111) is $3.25 and the average adjusted cost per square foot in Column 14, Table 4 is $3.05.

The adjusted cost was arrived at by comparing the as built school with the norm school. Savings were realized by adjusting special condition foundations, eliminating long span structures where intermediate supports could be accommodated, and substituting slab on grade for crawl spaces where acceptable.

The cost of the structure for cases 11E and 3S are high compared with the average. These high costs are due mainly to a complex structural system to satisfy intricate functional layouts. If these two cases are eliminated from the list, the average cost of the remaining schools is $2.88 per square foot of gross area. On this basis, we established the budget unit cost at $2.90 per square foot detailed as follows:

## 2.2 STRUCTURAL-Unit Costs (cont'd)

Single Story Building

| | |
|---|---|
| (i) Foundations | $1.40 |
| (ii) Superstructure | 1.50 |
| Total | $2.90 |

Multi-Story Building

| | |
|---|---|
| (i) Foundations | $1.00 |
| (ii) Superstructure | 1.90 |
| Total | $2.90 |

The foundation cost includes either the typical spread footing on competent bearing strata at frost free depths or cast-in-place encased drilled piling with grade beams.

### 2.2.6 School Visits

School visits consisted of a general inspection of existing conditions in the schools included in the Study. Thirty five schools located in various parts of the province were visited.

Generally, the structures were satisfactory for the purposes for which they were designed. The following deficiences were observed during the visits:

#### 2.2.6.1 Masonry Walls

a) unsightly cracking caused by differential settlements,

shrinkage and incompatibility of strains with other structural members.

b) painting expansion joint material resulted in peeling of paint when such joints expanded and/or contracted.

c) some large openings with block lintels showed signs of distress.

2.2.6.2 Long Span Structural Members

a) where long spans are used to cover open areas, those members supporting movable partitions or folding doors often deflect excessively rendering the partitions or doors inoperative.

b) on flat roof construction, long spans result in ponding of water and poor roof drainage due to excessive deflection.

2.2.6.3 Floor Slabs on Grade

a) depressed floors in areas of high water table have resulted in some water seepage through the slab.

b) poor soil conditions in some areas have caused uneven heaving and/or settlement, resulting in damaged floors.

c) some basement slabs have shown excessive cracking from shrinkage and lack of sufficient contraction and expansion joints.

2.2.6.4 Precast

a) Where precast, prestressed tees are used as floor construction in shop areas, some difficulty has been experienced in anchoring machinery to the floor due to the thin floor slab encountered in this type of construction.

b) Some precast prestressed member connections showed distress from non ductile connections which did not allow for adequate end rotations and bearing stress concentrations.

2.2.6.5 Glued Laminated Timber

Reduction of moisture content in glued laminated timber caused checking.

2.2.7 Observations and Comments

1. Cost of conventional footings on competent bearings at frost free depth are comparable to cast-in-place bored piles (25 foot depth) with shallow grade beams.

2. Single story buildings with floors as slabs on grade are more economical than those with crawl spaces or basements.

3. Multilevel sites or sloped sites add to foundation costs.

4. Foundation costs per gross square foot of building decrease with an increase in the number of stories.

2.2 STRUCTURAL--Observations and Comments (cont'd)

5. Foundation costs of single story schools offset the additional costs of superstructure in multistory schools.

6. Where standard and repetitive structural elements were employed on a regular grid with classroom spans in the order of 28 feet to 32 feet an overall economy of all disciplines was realized.

7. Structural cost advantages were achieved when permanent masonry partitions were used as a structural element in smaller schools.

8. Hybrid wood-steel joists, plywood decking with a fireguard ceiling supported on load bearing partitions is an economical single story superstructure.

9. Precast structures in the cases studied were not as economical as other systems. This is contrary to findings in some other provinces of Canada.

10. A high percentage of non standard, non repetitive precast in a structure adds appreciably to the overall cost of a school.

11. Although examples of multistory schools were limited to 2 and 3 floors, we found that structural square foot costs could be further reduced by adding floors to an optimum governed by other disciplines.

12. New structural design techniques such as computer analysis, ultimate design theory, new high strength materials and more mechanized

2.2 STRUCTURAL - Observations and Comments (cont'd)

construction procedures have resulted in offsetting proportional labor and material price increases.

13. Regional structural cost differences were not apparent in the Study.

14. The structural budget costs do not include allowances for any architectural costs such as the fullcost of interior or exterior walls, finishing of exposed elements or special structures for architectural effects.

15. The design structures in the study appear to be of good quality and in accordance with the N.B.C. code requirements.

## 2.3 MECHANICAL

### 2.3.1 Design Criteria

The following design criteria was followed in establishing the acceptable standards to which the norm school mechanical system must be designed:

- -The American Society of Heating Refrigeration and Air Conditioning Engineers Guide and Data Book for establishment of heating and cooling system capacity and certain ventilation standards.
- -The Industrial Ventilation Manual of Recommended practice by the Committee on Industrial Ventilation of the American Conference of Government Industrial Hygenists for special ventilation system requirements.
- -The Alberta School Buildings Handbook.
- -The National Building Code and the Province of Alberta Department of Public Health Regulation for plumbing systems.
- -The National Building Code for fire protection standards with due consideration to the influence of City of Edmonton and City of Calgary fire protection by-laws.
- -The Incinerator Standards of the Province of Alberta Department of Public Health.

2.3 MECHANICAL (cont d)

2.3.2 Elementary Schools

2.3.2.1 Selection of Schools

In the selection of schools to be analysed in depth, efforts were made to obtain a representative sampling of mechanical systems covering both the full range of design and cost variations.

Out of the 17 elementary schools studied 9 were selected for in depth study since this group contained a representative sampling of those systems. The average mechanical cost per square foot for the 17 schools was $3.38 ($1.14 for plumbing and $2.24 for heating and ventilation.)

In general no air conditioning system was provided.

2.3.2.2 Norm School

The selection of the mechanical system for the norm school was based on the review of systems in use and their compliance with the codes mentioned previously.

The following outline of components represent those most commonly utilized and found to be giving a satisfactory level of service. The budget for the mechanical system has been established on this basis.

2.3 MECHANICAL - Elementary Norm School (cont'd)

Plumbing

Waste Systems - Include standard installation as required by the National Building Code and the Department of Health Regulations. Cast iron pipes are used for underground lines under buildings and stacks and galvanized steel or copper DWV for connections of fixtures requiring connections less than 3" size above grade.

Water Supplies. Connections to City service are made in 2 inch or 2-1/2 inch copper water service to water meters provided by the utility. Include distribution piping systems of copper type "L" with streamline fittings and copper to copper valves. Valves to be provided in all main branch circuits and individual fixtures to be provided with shut off stops. Water distribution for wet standpipe systems installed in Schedule 40 steel pipe with 150 lb. malleable fittings.

Plumbing Fixtures. Selected for durability and service. Water closets for student washrooms are free standing floor mounted units complete with chrome plated flush valve connections and open front plastic heavy duty seats.

Water closets for teachers are flush tank type with heavy duty plastic seats.

Urinals are generally floor mounted stall units complete with flush tank and concealed distribution pipe. Urinals are installed flush with floor.

Lavatory basins for student washrooms are equal to cast iron wall hung with 8 inch centre supply and p.o. plug.

Janitor service sinks are free standing cast iron complete with wall hung supply with pail hook and brace.

Drinking fountains are wall hung vitreous china complete with bubbler and stream regulator.

Wet Standpipe Systems. Include standard pipe as mentioned above. Fire hose cabinets 30 x 30 x 9 complete with glass door. 75 ft. 1-1/2 inch unlined hose, 1-1/2 inch chrome plated valve, 1-1/2 inch combination spray and straight stream-nozzle with shut off. Include a 2-1/2 gallon pressurized water extinguisher or pump tank in each cabinet.

Service Connections - There is a wide diversity in the degree and length of service connections in the schools studied and the general siting of the school on the property provided would determine this length. We consider the norm school as one which is set back 80 to 100 feet from the property line with direct

connections to the services in the street, but mechanical designers should press for these connections to be as short as possible.

Domestic Hot Water. Include direct gas fired storage water heaters, with two storage heaters of approximately 80 US gallons storage and 100 US gph rise through 100 deg. F. each for a school of approximately 30,000 sq. ft. Include one hot water recirculation pump and thermostat. This size and capacity, however, must vary with the size of school and its facilities.

Classrooms and Ancillary Spaces. Include a single compartment stainless steel sink complete with hot and cold water services and drinking fountain bubbler.

Corridors. Include drinking fountains in the ratio of one to each 75 pupils, preferably near playground entrances and gymnasiums. Also provide fire protection equipment, i.e. fire hose cabinets with wet standpipe and/or hand fire extinguishers to code requirements. 50% of the schools studied were equipped with wet standpipe fire protection system.

Gymnasium. No plumbing equipment is included.

Libraries. No plumbing equipment is included.

Offices and Miscellaneous Areas. Include the necessary facilities for teachers washrooms, lunch room, work room and service rooms.

Roof Drainage System. Include standard flow roof drains sized in accordance with National Building Code and local Plumbing By-laws and connected to cast iron rain water leaders and storm collection systems.

Parking Lot Drainage. There is provision for one catch basin with connection to municipal storm sewer in the norm school.

Heating

Main Components. The norm school has hot water heating boilers, gas fired and approximately 50% of those studied had multiple installations with standby and future reserve capacity. Of the 17 elementary schools studied, only four were all air systems using furnaces and multizone heating units. We have, therefore, assumed the norm school to have cast iron sectional boilers each designed for 70% of the presently installed heating and ventilation capacity of the system.

Include pump units for radiation systems and ventilation units coil systems separately with a standby pump for the

radiation circuit, pumps being base mounted complete with vibration isolation and flexible couplings.

Radiation water supply temperature should be controlled by indoor-outdoor temperature control on a 3 way valve varying the water temperature in relation to the outdoor temperature. Reheat coils supplied with water from the same circuit. Heating water for ventilation unit coils should be regulated by constant flow control but varying the temperature of water with a 3 way valve controlled from the unit discharge air temperature. Reset should be provided to increase supply temperature as outdoor temperature falls. The gymnasium unit should be controlled similarly with constant flow-varying temperature using a 3 way valve controlled by room temperature.

Include all necessary appurtenances, expansion tanks, system thermometers, pressure gauges, air vents, chemical feeders, etc.

Classrooms and Ancillary Spaces. Include sufficient perimeter wall fin hot water heating radiation and cover to provide for transmission heat losses and infiltration losses of classrooms. Radiation for each room thermostatically controlled by throttling

valves. In interior rooms, the ventilation system should provide the heat required to compensate for the losses through the roof, using thermostatically controlled reheat coils.

Corridors. Entrances to be heated using force flow units or hot water projection heaters. No corridor radiation units are considered necessary.

Gymnasium. Use combination heating and ventilating units with no provision for humidification. Air distribution at floor level. Approximately 4 air changes are required based on total volume of the gymnasium and stage area with 20% minimum fresh air, with relief exhaust up to 100% of capacity of the supply system.

Offices and Miscellaneous Areas. Include thermostatically controlled hot water wall fin radiation complete with cabinet and/or convector units for perimeter areas. Interior spaces roof heat loss to be provided in the ventilation system, similar to that for interior classrooms.

Libraries. Since most library spaces are interior, the heating systems should be as previously described for interior rooms by using reheat coils and ventilation system. Where there is greater volume than normal classroom space the air change rates may

be reduced in proportion to approximately 5 air changes per hour and the minimum fresh air admitted to 20% of the total air circulated.

Ventilation

Main Components. The norm school in this case was more difficult to select since the system designs vary more widely. However, the norm school, i.e. 75% of those studied were equipped with heating and ventilating units using various combinations of fan configurations which would fit into space provided, the cabinet type fan unit being the most common. Return air fans were included in 10 out of 14 systems not employing furnace or roof top multizone systems, therefore, return air fans are also considered as standard on the norm school. Heating and ventilating systems employ various methods of humidification but, in keeping with the quality of the above system, a water spray humidifier using cold city water under pressure to spray nozzles will be considered as normal. Humidification systems should be designed to maintain a minimum of 20% RH in the building when the outdoor temperature is -30 deg. F. It must be recognized that window and wall construction will not permit the use of

humidity ratios much higher than 20% during extreme winter conditions without the risk of condensation.

The gymnasium supply systems as mentioned in heating above, employ the use of heating and ventilation units with underfloor supply systems and relief exhaust; no humidifiers are included for these systems.

Ventilation systems include a mixed air temperature controller which is set to provide approximately 20% minimum fresh air. Based on minus 30 deg. F. fresh air, 75 deg. F. return air and 20% fresh air, the mixed air temperature would be .20 x -35 = -7 and .80 x 75 = 60 to give 60 - 7 = 53 deg. F. which is generally regarded as normal air supply temperature required for free cooling. The ventilation heating coils may be controlled by a discharge, or return, air temperature controller with manual reset to provide additional heat if necessary.

Exhaust ventilation systems are connected to roof mounted exhaust fans with a varying number of fans depending upon the building layout, proximity of washrooms, etc. In general washroom exhaust should be based on 2 cfm/ sq. ft. of washroom and storage rooms 1 to 1.5 cfm per square foot of room area.

Classrooms and Ancillary Spaces. Air supply and return from central system source should provide for adequate circulation of air and fresh air as required by Design Criteria of 2.3.1 above. Approximate average of 6.5 air changes per hour for ventilation with a minimum of 300 cfm fresh air has proven satisfactory.

Offices and Miscellaneous Areas. Air supply and return from central system should provide for adequate circulation of air and also for fresh air requirements. A ventilation system designed for 8 air changes per hour with a minimum of 20% fresh air has been satisfactory.

Miscellaneous Systems

Incineration. Approximately 50% of the elementary schools studied are supplied with incinerators and we found that generally these were oversized compared to the incinerator standards of the province. An incinerator required for a school of approximately 30,000 sq. ft. would be 75#/ hr. capacity of No. 1 and 2 waste, but incinerators of 100#/hr. could be considered acceptable since cost difference is small. Unit capacities up to 240#/hr. have been installed in some instances.

2.3 MECHANICAL - Elementary School (cont'd)

2.3.2.2 Unit Costs

The average actual cost of mechanical installations for the 9 schools for which a more detailed study was undertaken was \$3.29 per square foot. Two of these were air conditioned.

The average cost of these same schools less case 2E adjusted to the norms given in section 2.3.2.2 was \$3.23 per square foot. (see Table 4). Thus we have taken \$3.25 as our budget figure.

2.3.3 Junior High Schools

2.3.3.1 Selection of Schools

Our general study covered 10 schools, 5 air conditioned and 5 not air conditioned. It is interesting to note that the actual mechanical cost per square foot of the air conditioned schools was slightly less than the average for non-air conditioned schools. This was due mainly to the fact that generally, the design concept of the schools had taken into account, that the building was to be air conditioned, was compact and of simpler layout enabling savings in the mechanical systems as well as in other components of the building. In those without air conditioning there were compensating cost features including evaporative cooling equipment.

2.3.3.2 Norm School

The selection of the mechanical system for the norm school was based on the review of systems in use and their compliance with the codes mentioned previously.

The following outline of components represent those most commonly utilized and found to be giving a satisfactory level of service. The budget for the mechanical system has been established on this basis.

Plumbing

Waste Systems. Include standard installation as required by the National Building Code and the Department of Health Regulations. Use cast iron pipes for underground lines under buildings and stacks and galvanized steel or copper DWV for connections of fixtures above grade requiring connections less than 3 inches in size.

Water Supplies. Connections to City service are made in 4 inch size with water meters provided by utility. Include distribution piping systems of copper type "L" with streamline fittings and copper to copper vales. Valves are provided in all main

branch circuits and individual fixtures to be provided with shut off stops. Water distribution for wet standpipe systems installed in Schedule 40 steel pipe with 150 lb. malleable fittings.

Plumbing Fixtures. Select for durability and service. Water closets for student washrooms are free standing floor mounted units complete with chrome plated flush valve connections and open front plastic heavy duty seats.

Water closets for teachers are flush tank type with heavy duty plastic seats.

Urinals are generally floor mounted stall units complete with flush tank and concealed distribution pipe. Urinals installed flush with floor.

Lavatory basins for students washroom are equal to cast iron wall hung with 8 inch centre supply and p.o. plug.

Janitor service sinks are free standing cast iron complete with wall hung supply with pail hook and brace.

Drinking fountains are wall hung vitreous china complete with bubbler and stream regulator.

Wet-Standpipe Systems. Include standard pipe as mentioned above, Fire hose cabinets 30 x 30 x 9 complete with glass door,

75 ft. 1-1/2 inch unlined hose, 1-1/2 inch chrome plated valve, 1-1/2 inch combination spray and straight stream nozzle with shut off. Include a 2-1/2 gallon pressurized water extinguisher or pump tank in each cabinet.

Service Connections. There is a wide variety in the type and length of service connections in the schools studied and the general siting of the school on the property would determine this length. We consider the norm school as one which is set back 80 to 100 feet from the property line with direct connections to the services in the street, but mechanical designers should work to have these connections as short as possible.

Domestic Hot Water. Include gas fired domestic water heating systems in conjunction with stone line storage tanks. Capacity of system should be equal to that recommended by ASHRAE with due consideration to an article in Volume 11 Number 8 of August 1969 of the ASHRAE Journal.

Classrooms and Ancillary Spaces. Approximately 50% of the classrooms include single compartment stainless steel sinks with hot and cold water supply. No bubblers are provided.

Corridors. Drinking fountains preferably near playground and gymnasium exits and fire protection equipment consisting of wet standpipe system and/or hand fire extinguishers. Approximately 50% of schools studied were found to have wet standpipe systems.

Gymnasium. Shower rooms with gang type showers for boys and individual stalls for girls are included. Drains should be provided in the locker room floors adjacent to the shower room to facilitate cleaning. Hot water temperature should be thermostatically controlled under the direct supervision of the gym instructor or teacher. Include single toilet facilities in each shower room and shower cabinet in gym instruction office.

Offices & Miscellaneous Areas. Include necessary facilities for teachers, e.g. washroom, lunchroom, workroom and service sinks.

Libraries. Include stainless steel sink with hot and cold water in library workroom.

Home Economics. A double compartment stainless steel sink with hot and cold water supply is included for each station plus rough-in plumbing for automatic washer.

Science Rooms. - Type 316 stainless steel science room sinks with

cold water only and demonstration disk sinkswith hot and cold water supplies are included. A large wash up sink with hot and cold water should be provided for clean up for each 12 to 16 stations.

Roof Drainage. Include standard flow roof drains sized in accordance with the National Building Code and local Plumbing By-laws and connected to cast iron rain water leaders and storm collection systems.

Parking Lot Drainage. There is provision for one catch basin with connection to municipal storm sewer.

Heating

Main Components. Include two hot water heating boilers sized for 70 percent of the total capacity of the heating and ventilation systems. Competitive prices should be obtained for steel fire tube boilers but care should be taken to eliminate thermal shock if these units are used instead of cast iron boilers.

As for the norm elementary school,base mounted pump units should be supplied for radiation systems, and ventilation coil systems with standby for the radiation circuit.

Radiation water supply temperature should be controlled by indoor-outdoor temperature control on a 3 way valve varying

the water temperature in relation to the outdoor temperature, and reheat coils supplied with water from the same circuit. Heating water for ventilation unit coils should be regulated by constant flow control but varying the temperature of water with a 3 way valve controlled from the unit discharge air temperature. Reset should be provided to increase supply temperature as outdoor temperature falls. The gymnasium unit may be similarly controlled with constant flow-varying temperature using a 3 way valvecontrolled by room temperature.

Include all necessary appurtenances, expansion tanks, system thermometers, pressure gauges, air vents, chemical feeders, etc.

Classrooms and Ancillary Spaces. Include sufficient perimeter wall fin hot water heating radiation and cover to provide for transmission heat losses and infiltration losses of classrooms. Radiation for each room thermostatically controlled by throttling valves. In interior rooms, the ventilation system should provide for the heat required to compensate for losses through the roof by use of reheat coils.

Corridors. Entrances are heated using force flow units or hot water projection heaters. No corridor radiation units are considered necessary.

## 2.3 MECHANICAL - Junior High Norm School (cont'd)

Gymnasium. Use combination heating and ventilating units with no provision for humidification, and with air distribution at floor level. Approximately 4 air changes are required based on total volume of the gymnasium and stage area, with 20% minimum fresh air and relief exhaust up to 100% of capacity of the supply system.

Office and Miscellaneous Areas. Include thermostatically controlled hot water wall fin radiation complete with cabinet and/or convector units for perimeter areas. Interior space roof heat loss to be provided in the ventilation system similar to that for interior classrooms.

Ventilation.

Generally with larger schools in this sector and increased material quantities, lower unit cost permits the use of more sophisticated systems. The use of the induction system becomes economically feasible and air conditioning more desirable to satisfy the requirements of the larger interior spaces.

Main System Components. There was a greater use of return air fan systems and all but one system not employing the rooftop multizone units was equipped with return fans. As was the case in the elementary schools, when rooftop multizone units were employed, return fans were not used. Considering the air

conditioned system as the norm, the basic supply systems would be similar to those provided for the norm elementary school except that cooling coil sections are added in the main supply air unit or units and spray coil humidification is incorporated.

Gymansium systems are similar to those provided in the norm elementary school with the same mixed temperature control.

Due to the inclusion of the cooling coils there is increased static pressure required for the fan systems. In the systems studied the designers made a greater use of medium velocity systems with single duct constant volume reheat boxes and/or induction units and this practice is recommended.

Shop supply systems generally incorporate the use of heating and ventilating units with heating coils only. Where shop supply units are provided, these should be designed for 100% outside air intake or matched to exhaust requirements. Consideration should be given to use of excess air from other sources, i.e. the normal exhaust air from central systems produced when balancing for the 20% minimum fresh air intake as a cost saving feature.

Exhaust ventilation systems should be connected to roof

mounted exhaust fans or vaneaxial fans, the number of which depends upon the building layout, proximity of washrooms and special exhaust requirements of shops, i.e. welding-carbon monoxide, etc.

As was the case for the norm elementary school, washroom exhaust should be 2 cfm per square foot of floor area, storage room, 1 to 1.5 cfm per square foot and special exhaust, as recommended by the Industrial Ventilation Manual.

Air Conditioning Equipment. There is a great variety of equipment employed with variations in each so that no two schools studied had identical installations though approximately the same level of performance being obtained for the same average cost.

The two air conditioned schools studied in detail had cooling equipment of 75 to 100 tons cooling capacity. Reciprocating chiller packages were used in conjunction with steel cooling towers. Chilled water from the chiller package circulated through the cooling coils of the main air supply equipment using 3 way mixing valves on the return for varying flow through the coil, controlled by an air discharge temperature controller.

Classrooms, Library and Ancillary Space. Air supply and return from central system source should provide for adequate circulation of air and fresh air as required by Design Criteria of 2.3.1 above. An approximate average of 6.5 air changes per hour for cooling and ventilation and a minimum of 300 cfm fresh air has proven satisfactory.

Office and Miscellaneous Areas - Supply and return distribution from central system should provide for adequate circulation of air and also for fresh air requirements. A cooling and ventilation system designed for 8 air changes per hour with a minimum of 20% fresh air has proven satisfactory.

Gymnasium - There is no provision for air conditioning.

2.3.3.3 Unit Costs

The average cost of the mechanical installations for 10 junior high schools included in the general study was $3.81 per square foot including air conditioning. Cooling equipment, chilled water and condenser water systems average $0.52 per square foot. If the cooling equipment is to be deleted, the budget for mechanical systems becomes $3.29 per square foot.

2.3 MECHANICAL (cont'd)

2.3.4 Senior High Schools

2.3.4.1 Selection of Schools

Of the seven senior high schools in our Study, two were selected for in depth analysis. Much more complete cost breakdown information was made available for all schools of this type and in spite of the limited number of schools in the Study the information was considered complete enough for comparison.

The average mechanical cost per square foot for all seven schools varied from $3.64 per square foot to $4.40 per square foot. Only one of the schools was not air conditioned and lacked only the refrigeration equipment to meet the standards of the others.

All the systems employed conventional medium velocity air distribution systems to terminal units (reheat, induction, double duct, etc.) Gymnasiums were not air conditioned nor were the shops.

2.3.4.2 Norm School

The following is a description of the basic components of mechanical system as observed for a norm senior high school. The mechanical systems for the norm senior high school are

generally more complex and employ the use of a greater variety of systems than used for the elementary and/or junior high schools due to a larger number of services provided and the diversity of the cooling and ventilation loads. The mechanical contract often includes items such as kitchen and shop equipment which are considered in our Study as integrated equipment. In order to analyse the mechanical systems on the same basis as the elementary and junior high schools, we have kept those items separate from the mechanical costs and these items are not included in the mechanical budget.

In all basic design aspects the requirements for junior and senior high schools are the same.

Plumbing

Waste Systems. Include provision for standard installation as required by the National Building Code and the Department of Health Regulations. Cast iron pipes are used for underground lines under building and all lines over 2-1/2 inch size. Smaller lines may be galvanized steel or copper DWV. Science room drainage requires the use of polyethylene acid proof drainage piping systems with dilution traps.

2.3 MECHANICAL - Senior High Norm School (cont'd)

Water Supplies. Connections to City service are made in 6 to 8 inch cast iron with water meter provided by the utility. Include distribution piping system of Schedule 40 galvanized steel for lines 4 inch and larger and copper type "L" with streamline fittings and copper to copper valves on lines 3 inches and smaller. Valves are provided in all main branch circuits and individual fixtures are provided with shut off stops. Water distribution for wet standpipe systems installed in Schedule 40 black steel pipe with 150 lb. malleable fittings.

Plumbing Fixtures. Select for durability and service. Water closets for student washrooms are free standing floor mounted units complete with chrome plated flush valve connections and open front plastic heavy duty seats.

Water closets for teachers are flush tank type with heavy duty plastic seats.

Urinals are generally floor mounted stall units complete with flush tank and concealed distribution pipe. Urinals are flush with floor.

Lavatory basins for student washrooms are equal to cast iron wall hung with 8 inch centre supply and p.o. plug.

Janitor service sinks are free standing cast iron complete with wall hung supply with pail hook and brace.

Drinking fountains are wall hung vitreous china complete with bubbler and stream regulator.

Bradley wash fountains are included for use in shop areas.

Service Connections. Since the general case involves larger schools more extensive connection requirements are necessary but the average includes the storm, sanitary and water connections based on 100 foot setback from the property line.

Domestic Hot Water. Due to the larger size of heating equipment, and the necessity for summer operation of boilers, the domestic hot water systems were generally supplied from the boilers using heat exchangers in the storage tanks. The average is not significant since size of schools vary considerably. Storage to heating capacity, however, is generally 1 to 1. Stone lined storage tanks are generally used.

Classrooms and Ancillary Spaces. Classrooms in the arts and sciences sections require sinks as designated by the school building program.

Corridors. Drinking fountains should be located in the public areas but not so that they impede traffic flow. As was the case

for elementary schools the users recommend that drinking fountains be located near playground exits. Fire protection equipment includes wet standpipe systems with hand fire extinguishers. There appears to be little value in providing 2-1/2 inch fire valves in cabinets of single and two story structures. Sprinkler systems must be provided to meet local code requirements.

Gymnasium. Shower rooms with gang type showers for boys and individual stalls for girls are included. Drains should be provided in the locker room floors adjacent to the shower room to facilitate cleaning. Hot water temperature should be thermostatically controlled under the direct supervision of the gym instructor or teacher. Include single toilet facilities in each shower room and shower cabinet in gym instruction office.

Offices and Miscellaneous Areas. Include necessary facilities for teachers, e.g. washroom, lunchroom workroom and service sinks.

Libraries. Include stainless steel sink with hot and cold water in library workroom.

Home Economics. A double compartment stainless steek sink with hot and cold water supply in included for each station with

rough-in plumbing for automatic washer.

Science Rooms. Type 316 stainless steel science room sinks with cold water only and demonstration desk sinks with hot and cold water supplies are included. A large washup sink with hot and cold water should be provided for clean up for each 12 to 16 stations.

Roof Drainage. Include standard flow roof drains sized in accordance with the National Building Code and local Plumbing By-laws and connected to cast iron rainwater leaders and storm collection systems. Control flow drains should be used where possible to reduce cost of drainage systems.

Parking Lot Drainage. There is provision for more yard work with connection to municipal storm sewer, particularly in connection with the larger parking lot areas.

Heating

Package fire tube steel boilers with automatic forced draft gas burners are generally installed in the senior high schools with two boilers providing standby and reserve capacity. Hot water perimeter heating systems to wall fin radiation, convectors, force flow units and/or unit heaters would be used. In the case where

induction units are employed the perimeter heat loss is taken care of through these units.

Roof heat losses are generally included in the capacity of the interior zone ventilation equipment.

Main Components. The use of steel package fire tube boilers is mentioned above and as is the case of junior high schools the designers should protect the boilers against thermal shock. Boiler capacity should be 140% of total installed system capacity.

Include base mounted pumps with vibration isolation and flexible couplings.

Radiation supply water temperature should be controlled by indoor-outdoor temperature controllers. In these larger systems a separate reheat circuit for interior space temperature control is feasible within the budget. Heating water for ventilation unit coils may be regulated by varying temperature with constant flow thus maintaining balanced pressure drop through the systems.

Include all necessary appurtenances, expansion tanks, system thermometers, pressure gauges, air vents, etc.

Corridors. As was the case in the other school types only entrance heating units are included, except where there

there are corridors on outside walls.

Gymnasiums. Use combination heating and ventilating units with no provision for humidification, and with air supply distribution at floor level. Approximately 4 air changes are required based on total volume of the gymnasium and stage area with 20% minimum fresh air and relief exhaust up to 100% of capacity of the supply system.

There is increasing pressure due to the more active sports program and increasing community use of schools to have these areas of air conditioned. Allowance for this feature has not been included in this budget. Until such time as demand for and use of the gymnasiums has materially increased, the air conditioning of this facility does not appear to be warranted.

Libraries, Offices, Miscellaneous Areas. Include thermostatically controlled radiation for perimeter areas. Interior space heat loss to be provided for in the ventilation system similar to that provided for interior classrooms.

Ventilation and Air Conditioning

No rooftop multizone units are used in these larger systems. As was the case for elementary schools classroom, ancillary and

library ventilation rates have been found to be satisfactory generally at 6.5 air changes per hour and offices, workrooms and miscellaneous areas at 8 air changes per hour. All of these areas would be provided with a minimum of 20% fresh air.

Main System Components. Of the seven systems studied three were combination systems using induction exterior and constant volume double duct, one was variable volume, two were constant volume reheat. Each of these systems employ the use of generally the same basic system components of mixed air control. Both draw through and blow through fan/coil combinations are used with success. Spray coil humidification is incorporated.

Shop areas are equipped generally with makeup ventilation equipment to match capacity of exhaust systems. As stated in the junior high school section it is suggested that re-use of exhaust air from the central ventilation system be considered for makeup if possible.

Refrigeration Equipment - Systems requiring units of more than 100 tons of cooling capacity are better served by centrifugal chiller compressors with remote counterflow cooling towers.

Miscellaneous Systems.

Incinerators. Provide to meet code requirements. Code requirements state 10 lbs. per room plus 1/4 lb. per student based on a four hour burning rate, therefore, a 40 room shool with 1200 pupils requires (400+300x4=185) a 200#/hr. incinerator.

2.3.4.3 Unit Costs

The average cost of mechanical installations for all the senior high schools studied was $4.06 per square foot out of which $1.09 is for plumbing and $2.97 for heating, ventilation and air conditioning. After making allowances for the norm school standards and deduction of cost items of integrated equipment the average adjusted cost for the two schools studied in depth (see Table 4) was $3.72 per square foot. We adopted $3.80 per square foot as the budget figure.

2.3.5 Summary of Unit Costs

From the above studies, it appears that a common budget for all schools can be established since the average cost of the non air conditioned school is $3.25 to $3.30 per square foot and the air conditioned school is $3.80 per square foot. It must be noted, however, that there are varying aspects of each type of school as indicated by the following Table 3.

2.3 MECHANICAL (cont'd)

TABLE 3

MECHANICAL COSTS

| ITEM | Elementary (8 cases) Not Air Conditioned Average Cost/sq.ft. | | Junior High (3 cases) Air Conditioned Average Cost/sq.ft. | | Senior High (2 cases) Air Conditioned Average Cost/sq.ft. | |
|---|---|---|---|---|---|---|
| | Actual | Adjusted | Actual | Adjusted | Actual | Adjusted |
| 1. Plumbing | 1.05 | 1.06 | 1.14 | 1.12 | 1.04 | 0.97 |
| 2. Heating & Ventilation | 2.50 | 2.19 | 2.47 | 2.70 | 2.94 | 2.76 |
| 3. Total | 3.55 | 3.25 | 3.61 | 3.82 | 3.98 | 3.71 |
| 4. Budget | | 3.25 | | 3.80 | | 3.80 |

2.3.6. General Comments

The architectual design plays an important part in the cost of mechanical installations. It has been established that very often a good part of the difference in cost between our proposed budget system and higher cost mechanical system was due to a poor location of the mechanical room, wide dispersion of washrooms or too much window area. To achieve an economical design a centrally locateo mechanical room and compact washroom layout is most important.

The following is a partial list of items which contribute to

2.3 MECHANICAL - General Comments (cont'd)

higher than norm costs:

- oversized equipment and systems
- refractory lined chimneys for gas fired equipment
- steam boilers used, complete with heat exchangers and condensate return systems, thus double conversion
- elaborate central control panels, complete with system schematics
- three way valves on all terminal reheat coils and boxes
- terminal reheat coils supplied for exterior as well as interior classrooms, with resulting duplication of heating capacity for exterior spaces
- medium velocity system of ductwork, complete with terminal constant volume boxes in small systems
- copper lined hot water storage tanks
- oversized incinerator.

Although the report has been written based on the use of hot water heating systems it is not the intention to restrict the design to that system only.

Warm air heating systems using gas fired furnaces and rooftop multizones are being used extensively for elementary and junior high schools in rural areas where more local competition can be expected from sheet metal subtrades, and these must be considered where budget considerations are of prime importance. Where warm air systems are used, the fan systems should run continuously to provide

2.3 <u>MECHANICAL - General Comments</u> (cont'd)

ventilation requirements. It was noted during the site visits that most furnace fan systems cycled on thermostatic demand and therefore continous ventilation was not being achieved.

Where warm air furnace systems are used, school boards must be made aware that historically these systems do not last the life of the building as do most hot water heating systems using cast iron boilers.

During visits to the schools the occupants and the building custodians were questioned in relation to how the mechanical systems were performing. As a general rule most occupants were satisfied that their systems were adequately performing after initial trouble spots had been eliminated. Systems had been in use only one to two years and maintenance records have not indicated any problems with the equipment provided.

Several custodians of the buildings did not appear to be properly trained in the operation of the mechanical systems nor did they appear to understand them. We would recommend that designers ensure that the custodians are adequately trained in accordance with their specifications.

The most common complaint received in regard to mechanical

systems was in regard to the serviceability of equipment. Small fan rooms with no room around the equipment to allow for proper cleaning and service were used all too frequently. Access to rooftop equipment through hatches is also unadvisable since the tendency to inspect and maintain the rooftop equipment during the long periods of cold weather is reduced particularly when the access if difficult.

There are many instances where local board or local code requirements would appear to make the school designed for that board or under that code more expensive. These excesses are usually of a minor nature and other considerations required for most designs often offset the special requirements for one area.

For those who would question the necessity to provide air conditioning in schools we would refer them to Chapter 4 of the 1968 ASHRAE Guide and Data Book. To further substantiate the statements made therein a norm classroom was selected and the heating and cooling loads determined. We found that the average termperature in Edmonton at 3 p.m. is in excess of 60 deg.F. on all but a few days in April and October and all days in May, June and September. This represents 50% of the days school is in session. We also established that when the outdoor

2.3 MECHANICAL - General Comments (cont'd)

temperature is in excess of 60 degress F. the norm ventilation system cannot provide the free cooling necessary to maintain the desirable maximum classroom temperature of 75 degress. F.

Assuming that air conditioning is not only desirable but necessary, what then are the costs? We have already stated that the capital cost of the refrigeration equipment, cooling towers, etc. is 52 cents per square foot. Operating costs including power, cooling water and chemical treatment based on 300 hours of full load operation are estimated at 4 cents per square foot per year. This cost, when compared to the additional cost of air conditioned to non air conditioned space in the real estate field, is very small.

Further study would be useful of the relationship between capital costs and operating costs of mechanical equipment. It is suggested that this study should include:

i) Studies of rooftop systems in regard to serviceability and life expectancy.

ii) Studies and recommendations of maintenance procedures for all types of mechanical system equipment.

iii) Detailed space requirement study in relationship to

mechanical systems to determine the adequate allowance for mechanical room.

iv) A time study on the use of some components of mechanical systems to determine the value in relationship to cost and use.

A number of items have been reported on such as utility connections and parking lot drainage which do not currently come under the grants provided for school construction nor are they in this budget. They do however warrant comments insofar as they are an integral part of the various aspects which affect the final costs of school plant.

Provision has not been made for air conditioning elementary schools insofar as their present use pattern differs sufficiently from junior and senior high schools to make this installation of less value. Should it be desired to air condition elementary schools, an additional 50¢ per square foot would be required as with other schools.

## 2.4 ELECTRICAL

### 2.4.1 Elementary Schools

#### 2.4.1.1 Selection of Schools

Out of 17 schools available for the Study, eight were selected for the in depth electrical study. This selection was made in order to obtain a good sampling as far as cost and design is concerned. The average cost of the electrical installations for the 17 schools was $1.50 per square foot and the average cost of the eight selected was $1.42 per square foot.

#### 2.4.1.2 Norm School

The norm for electrical installations in elementary schools was arrived at through study and consideration of the plans and specifications of the schools selected, and by examination of the actual installations in these schools through site visits. This norm represents the type of electrical installation most commonly provided by the designers to meet the requirements of School Boards and local codes with some minor adjustment, to produce a design considered as an acceptable environment for learning. This norm can be described as follows:

Power Supply - Generally, power is supplied by means of

2.4 ELECTRICAL - Elementary Norm School (cont'd)

a primary underground service to a pad mounted transformer installed by the utility, and located adjacent to the school at a point as close as practical to maintain a short secondary underground service to the main distribution panel. This panel is located as close as possible to the centre of the load, usually in the mechanical equipment room. The secondary service is 120/208 volts, 3 phase, 4 wire to provide a maximum of 6.5 VA per square foot. The average connected lighting load was 2.6 VA per square foot. In the eight elementary schools studied, the average demand was 2.9 VA per square foot. This would indicate that services installed providing 6.5 VA per square foot, are sufficiently sized to carry some future additions or alterations.

Main distribution panels generally consist of moulded case, circuit breakers complete with metering current transformers.

Emergency Power - The norm school is equipped with an emergency power system utilizing a gas driven motor generator. The normal system provides for a maximum of 0.15 watts per square foot for lighting corridors and means of egress. The generator is rated at 120/240 volt, 1 phase, 3 wire which facilitates the use of the normal lighting fixtures on the emergency system.

Lighting

Classrooms Lighting levels in classrooms are generally 100 FC maintained, obtained by 2/40 watt rapid start surface mounted fixtures, with nominal 12 inch acrylic wrap around plastic lens. Fixture wattage installed should not exceed 3.2 VA per square foot of classroom area.

Gymnasiums Lighting levels in gymnasiums should not exceed 50 FC unless being used for examinations in which case, 75 FC are permissible. Generally fixtures are fluorescent or mercury, with wire guard, with a maximum of 1.5 VA per square foot installed to obtain this lighting intensity of 50 FC.

Corridors Fixtures installed in corridors are generally surface mounted with an acrylic lens, to produce 30 - 40 FC, using 1.2 VA per square foot.

Exterior Exterior lighting is provided at entrances and exits. Some floodlighting is included with the fixtures mounted on the building parapet.

Stage Lighting Minimal stage lighting is included, consisting of six front of stage spots, with eight 150 watt swivel fixtures mounted behind the proscenium arch. Dimmers and

channel mounts are not required.

Fire Alarm System Fire alarm system is an open circuit, supervised, non-coded local system complete with break-glass stations, automatic detectors and gongs for general evacuation.

Sound and Intercom System Consists of a main console with two channels, one for intercom and one for program, complete with AM-FM tuner, record player, signal tone generator, selector switches, all-call feature and annunciator. Classrooms have speakers with "talk-listen privacy" switch. Gymnasiums have speakers together with microphones and audio visual inputs. All wiring is run in EMT or PVC pipe.

TV System Conduits and splitter boxes only are included to all teaching areas for future TV antenna distribution systems.

Clock System A 4 circuit program signal controller is included to control outside horns, and tone generator in the sound console. Individual 110 volt clocks are included in corridors, gymnasium, open teaching area and office only. Clocks are not included in classrooms.

Telephones A two inch underground telephone service

entrance conduit terminated in a telephone cabinet, complete with telephone outlets in the general office area connected to this cabinet, is included.

Miscellaneous Systems Low voltage switching is used in the large open teaching areas. Elsewhere line voltage switches are used for the various individual rooms.

Wiring is provided to the various heating and ventilating equipment motors with all motor starters included in the electrical installation. Two or three receptacles are provided in each classroom with one located to suit the TV monitor. In addition, receptacles are provided in corridors and elsewhere with at least one receptacle for each room. Generally, one duplex outlet is provided in the parking lot for each 3,000 square feet of school area to serve as car heater outlets.

2.4.1.3 Unit Costs The major electrical components and various systems in each of the eight elementary schools studied, were evaluated and costs adjusted to conform to the requirements of the "norm" electrical installation as described above.

The average adjusted cost of these schools amounted to \$1.50 per square foot and this has therefore been set as the

electrical budget for elementary schools.

Recent tender calls confirm that designers are producing good designs within this budget and the figure of $1.50 is therefore, realistic.

### 2.4.2 Junior High Schools

#### 2.4.2.1 Selection of Schools

Out of the 12 junior high schools available for the Study, four were selected for a detailed electrical analysis. This selection was made in order to obtain a good sampling as far as cost and design are concerned. The average cost of the 12 junior high schools was $1.60 per square foot and the average of the four selected was $1.50 per square foot.

#### 2.4.2.2 Norm School

The norm for electrical installations in junior high schools was arrived at through study and consideration of the plans and specifications of the schools selected, and by examination of the actual installations in these schools through site visits. This norm represents the type of electrical installation most commonly provided by the designers to meet the requirement of School Boards and local codes with some minor adjustment, to produce

a design considered as an acceptable environment for learning. This norm can be described as follows:

Power Supply - Generally power is supplied by means of primary underground service to pad mounted transformer installed by the Utility, and located adjacent to the school at a point as close as practical to maintain a short secondary underground service to the main distribution panel. This panel should be located as close as possible to the centre of load.

The secondary service is usually 120/208 volt, 3 phase, 4 wire to provide a maximum of 6.5 VA per square foot. The average connected lighting load was 2.6 watts per square foot. The average power peak demand for non air conditioned junior high schools studies was 2.3VA per square foot and for air conditioned schools, 3.1 VA per square foot. This provides some allowance for future additions and alterations.

This would indicate that services installed providing 6.5 VA per square foot, are sufficiently sized to carry some future additions or alterations. Main distribution panels generally consist of moulded case circuit breakers with current transformers incorporated for Utility metering.

2.4 ELECTRICAL - Junior High Norm School (cont'd)

Emergency Power The norm school is equipped with an emergency power system utilizing a gas driven motor generator. The normal system provides for a maximum of 0.20 watts per square foot for lighting corridors and means of egress. The generator is rated at 120/208 volt, 3 phase, 4 wire which facilitates the use of the normal lighting fixtures on the emergency system.

Lighting

Classrooms Lighting levels in classrooms are generally 100FC maintained, obtained by 2/40 watt rapid start surface mounted fixtures, with nominal 12 inch acrylic wrap around plastic lens. Fixture wattage installed should not exceed 3.2 VA per square foot of classroom area.

Shops Lighting levels, in shops are generally 100 FC maintained, obtained by suspended industrial fluorescent fixtures or 400 watt mercury fixtures. Fixture wattage installed should not exceed 2.9 VA per square foot.

Gymnasiums Lighting levels in gymnasiums should not exceed 50 FC unless being used for examinations in which case, 75 FC are permissible. Generally, fixtures are fluorescent or mercury with wire guard, with a maximum of 1.5 VA per square foot

installed to obtain this lighting intensity of 50 FC.

Corridors Fixtures installed in corridors are generally surface mounted with an acrylic lens, to produce 30 - 40 FC using 1.2 VA per square foot.

Exterior Exterior lighting is provided at entrances and exits. Some floodlighting is included with the fixtures mounted on the building parapet.

Stage Lighting Included is one channel mount 24 feet long, two channel mounts, 4 feet long, six circuit 12 KW dimmer and 12 fixtures.

Fire Alarm System Included is a closed circuit, supervised zoned non-coded, local system complete with annunciator, break-glass stations, automatic detectors and gongs for general evacuation.

Sound and Intercom System Consists of a main console with two channels, one for intercom and one for program, complete with AM/FM tuner, record player, signal tone generator, selector switches, all-call feature and annunciator. Classrooms have speakers with "talk-listen-privacy" switch. Gymnasiums have speakers, with audio-visual inputs, together with microphone inputs.

2.4 ELECTRICAL - Junior High Norm School (cont'd)

TV System - Conduits and splitter boxes only are included to all teaching areas for future TV antenna distribution systems.

Clock System - A 4 circuit synchronous motor driven program signal controller is included to control outside horns, and the tone generator in the sound console. Individual 110 volt clocks are included in corridors, gym, shops, library and home economics areas. Clocks are not included in all classrooms.

Telephones - A two inch underground telephone service entrance conduit terminated in a telephone cabinet, complete with telephone outlets in the general office area connected to this cabinet, is included.

Miscellaneous Systems - Low voltage switching is used in the large open teaching areas. Elsewhere line voltage switches are used for the various individual rooms.

Wiring is provided to the various heating, ventilating and air conditioning equipment motors with all motor starters included in the electrical installation. Two or three receptacles are provided in each classroom with one located to suit the TV monitor. In addition, receptacles are provided in corridors and elsewhere with at least one receptacle for each room. Generally, one

duplex outlet is provided in the parking lot for each 3,000 to 3500 square feet of school area to serve as car heater outlets.

Wiring is also included to the electrical equipment in the Industrial Arts and Home Economics areas.

2.4.2.2 Unit Costs - The major electrical components and various systems in each of the junior high schools studied, were evaluated and costs adjusted to conform to the requirements of the "norm" electrical installation as described above.

The average adjusted cost of these schools amounted to $1.52 per square foot for schools with air conditioning and $1.49 per square foot for schools without air conditioning. The figure of $1.55 has been set as the electrical budget for junior high schools.

### 2.4.3 Senior High Schools

#### 2.4.3.1 Selection of Schools

Out of eight senior high schools available for our Study, four were selected for an in depth electrical study. The average cost of the eight schools was $2.09 per square foot and the average cost of the four studied in detail was $2.03 per sq. ft.

The selection was made in order to obtain a good sampling as far as cost and design are concerned.

2.4.3.2 Norm School

The norm for electrical installations in high schools was arrived at through study and consideration of the plans and specifications of the schools selected, and by examination of the actual installations in these schools through site visits. This norm represents the type of electrical installation most commonly provided by the designers to meet the requirements of School Boards and local codes with some minor adjustment, to produce a design considered as an acceptable envirnment for learning. This norm can be described as follows:

Power Supply - Generally, power is supplied by means of a 13.2 KV primary service with primary switchgear, secondary switchgear and transformers included as a part of the school design and cost. This switchgear is centrally located and power is distributed from it at 347/600 volts or 277/480 volts, 3 phase, 4 wire. Dry type transformers are located throughout the school to further transform this distribution voltage to 120/208 volts for receptacles, incandescent lighting, etc.

The average maximum demands for the schools studied, including air conditioning was 3.56 VA per square foot. The highest demand encountered on any school was 4.35 VA per square foot. As for elementary and junior high schools, it would appear that 6.5VA per square foot is generally ample provision in the electrical capacity for senior high schools unless known future additions are contemplated.

Primary switchgear generally consists of fused interrupter switches, and secondary switchgear consists of air circuit breakers and moulded case circuit breakers selected for the short circuit interrupting capacity required.

Emergency Power - The norm school is equipped with an emergency power system utilizing a gas driven motor generator. The normal system provides for a maximum of 0.20 watts per square foot for lighting corridors and means of egress. The generator is rated at distribution voltage, 3 phase, 4 wire which facilitates the use of the normal lighting fixtures on the emergency system.

Lighting

Classrooms - Lighting levels in classrooms are generally

100FC maintained, obtained by 2/40 watt rapid start surface mounted fixtures, with nominal 12 inch acrylic wrap around plastic lens. Fixture wattage installed should not exceed 3.2 VA per square foot of classroom area.

Shops- Lighting levels in shops are generally 100 FC maintained, obtained by suspended industrial fluorescent fixtures or 400 watt mercury fixtures. Fixture wattage installed should not exceed 2.9 VA per square foot.

Gymnasium - Lighting levels in gymnasium should not exceed 50 FC unless being used for examination in which case, 75 FC are permissible. Generally fixtures are fluorescent or mercury, with wire guard, with a maximum of 1.5 VA per square foot installed to obtain this lighting intensity of 50 FC.

Corridors - Fixtures installed in corridors are generally surface mounted with an acrylic lens to produce 30 - 40 FC using 1.2 VA per square foot.

Exterior - Exterior lighting is provided at entrances and exits. Some floodlighting is included with the fixtures mounted on the building parapet.

Stage Lighting - An allowance in amount of 6¢ per square

foot has been included for supply of the stage lighting equipment. It is considered that this amount will allow an acceptable stage lighting system including channel mounts, dimmers, quick connect panel, floor pockets, and fixtures.

Fire Alarm System - Included is a closed circuit, supervised, zoned non-coded, local system complete with annunciator break-glass stations, automatic detectors and gongs for general evacuation.

Sound and Intercom Systems - All allowance in amount of 11¢ per square foot has been included for the supply and installation of a sound and intercom system. It is considered that this amount will allow an acceptable system generally described as follows:

a) The sound system would be a two channel system, complete with AM/FM tuner, record player, signal tone generator, all-call feature for paging. Speakers would be included in classrooms, corridors, gymnasiums, etc. A portable PA system is included.

b) The intercom system would be an internal manual telephone system complete with telephone handsets at each local.

2.4 ELECTRICAL - Senior High Norm School (cont'd)

TV System - Conduit and splitter boxes only are included from a possible central studio location to all teaching areas for future TV antenna distribution systems.

Clock System - A six circuit synchronous motor driven master clock and program signal controller, together with synchronous wired indicating clocks is included. Clocks are included in corridors, cafeteria, library, shops, auditorium and major study areas, but not in all classrooms.

Telephones - A two inch underground telephone service entrance conduit terminated in a telephone cabinet, complete with telephone outlets in the general office area connected to this cabinet, is included.

Miscellaneous Systems - Wiring is included to all heating, ventilating and air conditioning motors with motor starters supplied as a part of the electrical installation. These starters are either individually mounted or are grouped in motor control centres.

Power supplies to the various industrial shop motors, welders etc. are included, with motor starters included as a part of the equipment. Each shop is wired to a separate panel arranged for

locking off power to equipment.

Minimal underfloor duct systems are included for language labs and typing rooms.

Wiring for variable AC/DC distribution systems, antenna systems and 120 volt outlets, is included for bench wiring in electrical and electronics labs. Minimal variable AC/DC supply equipment is included.

Wiring to kitchen and cafeteria equipment is included as a part of the electrical installation. Parking lot outlets for car heaters are included based on one duplex outlet per 3600 to 4000 square feet. Minimal parking lot lighting is included. 277 and 347 volt line voltage switching is included and utilized to a maximum extent. Use of low voltage switching is minimized.

Receptacles are included with at least one installed in each room, and at each possible TV monitor location.

2.4.3.3 Unit Costs

The major electrical components and various systems in each of the four senior high schools studied, were evaluated and costs adjusted to conform to the requirements of the "norm"

electrical installation as described above. The average adjusted cost of these schools amounted to $1.90 per square foot and this has therefore been set as the electrical budget for senior high schools.

Recent tender calls confirm that designers are producing good designs within this budget and the figure of $1.90 is therefore considered realistic.

### 2.4.4 Summary of Unit Costs

A summary of the unit cost established in Section 2.4 gives the following detailed budgets per square foot.

- $1.50 for elementary schools, not air conditioned
- $1.55 for junior high schools, air conditioned
- $1.90 for senior high schools, air conditioned and including primary substations.

### 2.4.5 General Comments

During the course of the study discussions were held with various parties including School Board officials, school personnel, architects, engineers, contractors and suppliers.

These discussions have brought forth worthwhile observations on practices which though not generally current should be brought to the

attention of school designers.

In most cases where the intercom facility is separate from the sound system, separate conduit is being run for each system. Single conduits could be run to accommodate both systems, and if multi-conductor cables or shielded cables were employed, the result would be satisfactory. Plastic pipes instead of steel pipes should be considered in many instances, as should running open wiring above accessible ceilings to decrease the cost of this system.

The need to communicate between classrooms is questioned on the intercom systems. Granted, there are certain areas in the school where there is need for intercommunication, for example, between department heads, the janitor, vice-principal, etc., however, this can readily be arranged on manual intercom systems without the use of an automatic dial exchange system.

Some School Boards are specifying custom built sound and intercom systems adding considerably to the cost of these systems. If standard manufactured systems could be employed there would be cost savings.

Certain schools contain emergency generators sized to operate the heating plant in addition to the emergency lighting. This practice is questioned, particularly in urban areas where the reliability of utili

power supplies is excellent.

Regardless of the quality of the lighting system installed, there appears to be few, if any, complaints in regard to this item. Teaching staff like a high level of lighting, however, they are not aware of quality considerations such as brightness, glare, etc. There are many instances where excessive amounts have been spent from a quality standpoint only and this does not appear justified due to the lack of complaint in regard to quality of lighting.

There are many instances where the lighting levels in corridors are excessive. Thirty to forty foot candles is adequate and in many instan ces the quantity is in excess of this amount. There are also instances where the quality of lighting fixture is excessive unless it is justified from an aesthetic standpoint.

There are many instances in regard to gymnasium where the lighting levels are excessive. Fifty foot candles is more than adequate to meet the requirements for sports. Some School Boards ask for seventy-five foot candles as these areas are sometimes used for examinations. There are, however, many instances where the lighting levels are far in excess of this figure and in some cases as high as two hundred foot candles.

Extensive underfloor duct systems have been provided in the

libraries of some senior high schools to allow for listening carrels. It would be much more economical to ascertain the exact location of these, and rough in conduit to their exact location rather than provide extensive underfloor duct systems which are only partially utilized.

The compactness of the school layout is a major factor affecting the cost of electrical distribution systems.

Generally, primary switchgear and transformers should be supplied and installed by the Power Company since this increased capital expenditure when incorporated as a part of the school cost, cannot be justified in relationship to the savings that accrue through purchasing power on a primary basis.

The location of the electrical room is important to facilitate this and should be considered during the early design stages.

It would appear desirable for School Boards and the Province to give considerable thought to the type of communication systems being installed in schools.

Considerable technological change is taking place in this area, and particularly in consideration of the trend for audio-visual aids compatibility of these systems through the Province will likely prove necessary.

2.4 ELECTRICAL - General Comments (cont'd)

Insofar as these developments are taking place at a rapid rate, close coordination with the agencies who will be responsible for transmission and utilization should be maintained so as to avoid installation of potentially redundant equipment.

There is a real need to evaluate and consider the following systems from and education standpoint to determine their adequacy and to ensure that their costs are justified in relation to the use obtained.

(a) Extent of clock coverage,

(b) Sound systems to determine whether the program channel is utilized effectively,

(c) Type of TV antenna distribution system required to meet the present and anticipated requirements of ETV,

(d) Type and extent of stage lighting system. Must each school be fully equipped or can additional equipment be requisitioned as required from central stores?

A number of components have been reported on in this report such as parking lot lighting and car plugins. Although they are not included in the normal grant formula or in this budget, they do in many cases form an integral part of the school cost and it was deemed worthwhile to deal with them.

## 2.5 GENERAL CONDITIONS

In order to facilitate the analysis of the various components of a building we have lumped under one heading the indirect general constractor's costs such as costs of insurance, bid and performance bond, site supervision, heating, cleaning, indirect materials, site overhead, profit, contingencies, etc.

We have found from the in depth study of the schools that the average of these costs are as follows:

- $1.50 per square foot for buildings up to 50,000 square feet.
- $1.30 per square foot for buildings between 50,000 square feet and 150,000 square feet.
- $1.10 per square foot for buildings larger than 150,000 square feet.

We have adopted these figures as our budget figures.

## 2.6 SPECIAL CONDITIONS

In the cases submitted for study none had exceptional conditions such as drilling of water wells, building of sewage disposal plants, extremely unusual foundation conditions or other such installations.

We have, on the other hand, observed that a number of schools required short pile foundations.

But in each of those cases the depth of piles was not greater than 25 feet and the savings on the footings were such that it compensated for the cost of the piles and even sometimes produced actual savings.

The total cost of the pile foundations was approximately the same as the standard foundations with walls and footings and, therefore, standard friction pile foundations up to a depth of 25 feet should not be considered as special conditions.

However, we recognize that there is a possibility that certain exceptional conditions could cause additional expenses. Each one should be studied and evaluated on its own merit. The construction budget suggested further in this report does not allow for those special conditions.

## 2.7 INTEGRATED EQUIPMENT

Integrated equipment includes items which are not necessarily part of the buildings but need to be installed at the time of construction. These intems include generally the following:

- counters and cupboards
- bookshelf units
- movable wardrobe
- study carrels
- overshoe racks
- shelving
- display cabinets
- chalkboard and tackboard
- understage chair storage dollies
- lockers
- stage drapes, tracks and curtains
- benches
- kitchen equipment
- some fixed shops equipment such as lifts, spray booths, etc.
- bleachers
- etc.

2.7 INTEGRATED EQUIPMENT (cont'd)

Depending on the architectural concept the items which need to be incorporated to the buildings vary from one school to another. It also varies for the three types of schools that is elementary, junior and senior high schools. It was observed that the following amounts are normally adequate to cover the cost of the above items:

- elementary schools = $0.80/sq. ft.
- junior high schools = $1.00/sq. ft.
- senior high schools = $1.30/sq. ft.

These amounts were used in the recommended budget.

2.8 SITE IMPROVEMENT

There was a wide range in the sums of money spent for site improvement which varied in proportion to the extent and complexities of the improvements made. It was found that the average cost of the site improvement was:

- $0.30/sq. ft. for elementary schools
- $0.30/sq. ft. for junior high schools
- $0.40/sq. ft. for senior high schools.

That would provide for:

- 1 parking place per 1500 square foot for elementary schools
- 1 parking place per 1600 square foot for junior high schools
- 1 parking place per 1800 square foot to 2000square foot for senior high schools.

The cost of site improvement is not included in the recommended budget.

2.9 CONTINGENCIES

The amount of $0.30 per square foot has been allowed for the contingencies. The actual exact average amount spent on this item could not be established due to the fact that many of the schools were recent buildings for which no such figures were yet available. The amount budgeted for by the School Boards was therefore used for our recommended budget and this amount seems adequate.

# RESEARCH PROJECT ON SCHOOL CONSTRUCTION

## CASE HISTORY ANALYSIS
## BUILDING COST / SQ. FT.
## SUMMARY

| CASE NUMBER | GROSS AREA (SQUARE FEET) | ARCHITECTURAL | | | | | | | | STRUCTURAL | | | | | | MECHANICAL | | | | | | ELECT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ROOFING | | EXT WALL | | INT WALL | | TOTAL | | FOUNDAT.ON | | SUPERST. | | TOTAL | | PLUMBING | | HEATING VENTILATION | | TOTAL | | TOTAL | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| | | | | | | | | 1+3+5 | 2+4+6 | | | | | 9+11 | 10+12 | | | | | 15+17 | 16+18 | | |
| | | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED | ACTUAL | ADJUSTED |
| 1E | 40,000 | | | | | | | | | | | | | | | | | | | | | 1.54 | 1.48 |
| 2E | 44,000 | | | | | | | | | 1.43 | 1.43 | 1.56 | 1.46 | 2.99 | 2.89 | 1.29 | 1.16 | 3.56 | 3.04 | 4.85 | 4.21 | | |
| 3E | 32,000 | 0.48 | 0.50 | 1.48 | 1.25 | 2.48 | 3.05 | 4.44 | 4.80 | 1.49 | 1.40 | 1.50 | 1.50 | 2.90 | 2.90 | 0.79 | 0.88 | 1.86 | 1.95 | 2.65 | 2.88 | 1.63 | 1.49 |
| 5E | 42,000 | 0.46 | 0.50 | 1.07 | 1.25 | 3.41 | 3.05 | 4.94 | 4.80 | 1.53 | 1.50 | 1.25 | 1.25 | 2.78 | 2.75 | 0.84 | 0.88 | 1.96 | 1.87 | 2.80 | 2.78 | | |
| 6E | 32,000 | | | | | | | | | 1.52 | 1.40 | 1.68 | 1.59 | 3.20 | 2.99 | 0.94 | 0.89 | 1.99 | 2.07 | 2.93 | 2.96 | 1.42 | 1.44 |
| 9E | 42,000 | | | | | | | | | | | | | | | 1.32 | 1.26 | 2.28 | 1.96 | 3.60 | 3.23 | 1.66 | 1.51 |
| 11E | 45,000 | | | | | | | | | 1.57 | 1.52 | 2.87 | 2.37 | 4.44 | 3.89 | | | | | | | | |
| 12E | 20,000 | 0.44 | 0.50 | 1.29 | 1.25 | 3.07 | 3.05 | 4.80 | 4.80 | 1.47 | 1.51 | 1.25 | 1.25 | 2.72 | 2.76 | 0.90 | 0.88 | 2.10 | 2.24 | 3.00 | 3.13 | 1.34 | 1.50 |
| 13E | 25,000 | 0.52 | 0.50 | 1.62 | 1.25 | 2.75 | 3.05 | 4.89 | 4.80 | 1.57 | 1.45 | 1.53 | 1.53 | 3.10 | 2.98 | 1.12 | 1.16 | 2.48 | 2.40 | 3.60 | 3.56 | 1.44 | 1.52 |
| 16E | 30,000 | 0.58 | 0.50 | 1.38 | 1.25 | 3.25 | 3.05 | 5.21 | 4.80 | 1.24 | 1.24 | 1.69 | 1.54 | 2.93 | 2.78 | 1.23 | 1.33 | 1.90 | 1.92 | 3.13 | 3.25 | 1.39 | 1.46 |
| 19E | 40,000 | 0.48 | 0.50 | 1.12 | 1.25 | 3.24 | 3.05 | 4.84 | 4.80 | 0.82 | 0.82 | 1.83 | 1.83 | 2.65 | 2.65 | | | | | | | 0.95 | 1.10 |
| | | | | | | | | | | | | | | | | | | | | | | | |
| 2J | 70,000 | 0.36 | 0.45 | 0.95 | 1.10 | 2.27 | 2.85 | 3.58 | 4.40 | 1.30 | 1.30 | 1.86 | 1.82 | 3.16 | 3.12 | 0.82 | 0.99 | 2.20 | 2.49 | 3.02 | 3.49 | 1.55 | 1.50 |
| 4J | 40,000 | | | | | | | | | | | | | | | 1.10 | 1.05 | 2.98 | 3.02 | 4.08 | 4.08 | 1.58 | 1.54 |
| 9J | 55,000 | | | | | | | | | | | | | | | | | | | | | 1.45 | 1.50 |
| 11J | 40,000 | 0.56 | 0.50 | 1.36 | 1.25 | 2.80 | 3.05 | 4.72 | 4.80 | 1.22 | 1.27 | 1.57 | 1.52 | 2.79 | 2.79 | 1.50 | 1.30 | 2.25 | 2.59 | 3.75 | 3.89 | 1.42 | 1.48 |
| | | | | | | | | | | | | | | | | | | | | | | | |
| 2S | 270,000 | 0.31 | 0.35 | 0.63 | 0.95 | 2.22 | 2.55 | 3.16 | 3.80 | 0.97 | 0.97 | 2.22 | 2.08 | 3.19 | 3.05 | 0.85 | 0.73 | 3.34 | 2.97 | 4.19 | 3.70 | 1.96 | 1.86 |
| 3S | 290,000 | | | | | | | | | 1.51 | 1.42 | 3.83 | 2.73 | 5.34 | 4.15 | | | | | | | 1.69 | 1.73 |
| 5S | 200,000 | | | | | | | | | | | | | | | 1.23 | 1.19 | 2.53 | 2.55 | 3.76 | 3.74 | 1.74 | 1.72 |
| 6S | 75,000 | 0.39 | 0.45 | | | | | | | | | | | | | | | | | | | 2.75 | 2.16 |

## PART III - CONSTRUCTION BUDGET

### 5.1 ESTABLISHMENT OF BUDGET

From the information gathered in Part II, the following construction budget has been established. This budget, it is felt, is adequate to construct the schools described previously in this report. The budget is shown in the following table.

TABLE 5

CONSTRUCTION BUDGETS

| | Elementary-non air conditioned | Junior High-air conditioned | Senior High-air conditioned |
|---|---|---|---|
| | COST/SQ. FT. OF GROSS AREA | | |
| 1. General Conditions | $ 1.50 | $ 1.30 | $ $ 1.10 |
| 2. Architecture | | | |
| a) Roofing | 0.50 | 0.45 | 0.35 |
| b) Exterior Walls | 1.25 | 1.10 | 0.90 |
| c) Interior walls & finishes | 3.05 | 2.85 | 2.55 |
| 3. Structure | | | |
| a) Foundations | 1.40 | 1.40 | 1.00 |
| b) Superstructure | 1.50 | 1.50 | 1.90 |
| 4. Mechanical | | | |
| a) Plumbing | 1.05 | 1.10 | 1.00 |
| b) Heating & Ventilation | 2.20 | 2.70 | 2.80 |
| 5. Electrical | 1.50 | 1.55 | 1.90 |
| 6. Integrated Equipment | 0.80 | 1.00 | 1.30 |
| 7. Contingencies | 0.30 | 0.30 | 0.30 |
| TOTAL | $15.05 | $15.25 | $15.10 |

3.1 ESTABLISHMENT OF BUDGET (cont'd)

It should be noted that these budgets do not include:

- Fees (architectural, engineering or others)
- Site development costs
- Land cost
- Sales tax credits
- Special conditions such as unusual site or soil conditions.

The above construction budgets should not be exceeded under normal conditions and apply to the present and expected conditions in the construction industry for the comming year unless drastic economic changes take place. Based on normal technological advancement and market conditions, designers should be able to work within these budgets and provide a satisfactory school plant.

There is a greater difference between the actual unit costs and the recommended budget for senior high schools than for the elementary and junior high schools. The study group has paid special attention to this situation and generally it was found that the senior high schools were designed with higher quality standards which added very little as far as the educational needs or durability of the buildings were concerned. Consequently, for a senior high school built in accordance with the standards established previously in this report, no change in the recommended budget was deemed necessary.

We recommend that the allocation for the various items of the budget

## 3.1 ESTABLISHMENT OF BUDGET (cont'd)

be redistributed to take into account particular design features of each individual project. Such an itemized budget should be agreed upon by the consultants concerned with the design and receive the owners approval.

Attention is drawn to the fact that the amounts used for the various items making up the total budget are not meant to be applied to every school. These amounts were established considering a conventional school. It is not the intention of the study group to suggest that all schools be built along the same basic architectural concept. Whenever necessary, the allocation for the various items should be redistributed to take into acount each individual project. If, for instance, it was decided that a certain school was to have exposed structural members in lieu of suspended ceilings, the detailed budget for that school would have a smaller amount allocated for interior finishes and a greater amount for the structure.

## 3.2 FACTORS AFFECTING THE BUDGETS

Table I, Page 9 gives the list of the various schools studied, their size, date of tender and their cost per square foot. An examination of this table shows that in actual fact there was no relation between the unit cost per square foot and the date of tender. Furthermore, the study group found that there was no pattern of relationship between the unit cost and either the location of the schools or their aesthetic value. These factors are, however, discussed in further detail later on in this section.

## 3.2 FACTORS AFFECTING THE BUDGETS (cont'd)

To explain this situation the various factors affecting costs will be reviewed as follows:

- Design concepts
- Detailing of plans
- Specification of materials
- Local code requirements
- Time of tendering:
  a) winter conditions
  b) market conditions
- Completion schedule
- Location of construction job.

### 3.2.1 Design Concepts

A complicated layout is invariably tied to a higher cost school. It influences the cost of all components of a school such as foundation structure, the mechanical and electrical systems. As mentioned in Part II, it also increases, generally, the ratio of exterior walls to floor area.

It is suggested that even with a compact layout, care in the design of structural, mechanical and electrical systems is

required to avoid increasing the cost of such installations unnecessarily, without increasing the performance of the buildings.

### 3.2.2 Detailing of Plans

Simplicity and uniformity of detailing will do much to reduce the cost of a building and in many instances will enhance its aesthetic value. In high cost schools it was observed that often, the details shown on the plans were unnecessarily complicated and uncoordinated. There was not enough repetition of elements to take advantage of volume purchasing. This also tended to create complications in ordering, delivery, storage, handling and installation on the construction site which was reflected in higher costs to the builders.

### 3.2.3 Specification of Materials

Concise and complete specifications are to be highly recommended. Cumbersome and too restrictive specifications will add unnecessarily to the cost. It was observed that in some cases the use of only one product was allowed. Where suitable alternate materials are available a competitive situation should result in lower costs. Also, the practice of including provisional sums for a number of items should be kept at a minimum.

Care and attention to the items mentioned including careful adherence to the proper ratios of such items as wall to floor area, percentage of window areas, systems concepts, should result in an economical plant. Failure to observe the concepts of good design can have a material effect on the cost of the building.

### 3.2.4 Local Code Requirements

Most school plants are built according to the requirements of the National Building Code. The major cities have their own amendments to this code which influences the design of certain components of buildings. It was found that these amendments did not affect the cost of any school buildings appreciably from one city to the other since each one has its own special requirements which seem to offset their individual effects on costs. Nevertheless, these code requirements should be rationalized.

### 3.2.5 Time of Tendering

#### 3.2.5.1 Winter Conditions

There is no doubt that if construction of a school takes place between March and November there is a saving in construction costs over one which is built between November

and May. The difference in cost to the general contractor is in the order of $0.15 per square foot.

In practice, however, seldom will the owner of a building benefit from all of this saving. The reason being, that very often the construction period extends for more than the seven months between March and November, and also a builder will normally anticipate, and make allowance for, some delay in delivery of some critical equipment or materials and delays in the performance of the subconstractors.

Therefore, the time of tendering, inasmuch as winter conditions are concerned, does not affect to any large extent the cost of a school plant.

3.2.5.2 Market Conditions

If a tender call for a school were to coincide with those of many other buildings, it can be expected that competition may be reduced and therefore the bids submitted may be accordingly higher.

This situation in the present highly competitive field of construction seems to happen seldom and only under

exceptional conditions. It is rather difficult to appreciate with any degree of accuracy the effect of such conditions. It his, however, doubtful that this has resulted in bids higher than 3 to 5% above normal or has increased the cost of a building by more than \$0.45 to \$0.75 per square foot in the schools studied. Care and attention should be paid to the number of tenders anticipated at any particular time so as not to overload the tendering procedures.

3.2.6 Completion Schedule

If for reason of urgency the completion of a new school was requested by the owner in such a short period that overtime or double shifts was required on the part of the builder, there is little doubt that the tender prices would be increased. The extent of this penalty, should, where possible, be determined in advance of tendering. Since this is a very exceptional situation, it should be treated as such and the budget adjusted accordingly. Under normal conditions a builder has much to gain by completing a construction project early and his efforts are normally directed to that end.

3.2 FACTORS AFFECTING THE BUDGETS (cont'd)

3.2.7 Location of Construction Job Site

One would expect that a school built in or near an urban centre would cost less than the same school built in a smaller centre or rural area, this because of the added cost of transportation and boarding of specialized tradesmen.

The average actual cost for schools outside of these centres was approximately 6% higher than the average of the Edmonton-Calgary area schools prior to adjustment. After adjustment there was no noticeable difference. Since other factors influence the cost such as the architectural layout and the choice of mechanical and electrical systems, etc., we cannot conclude that these statistics represent necessarily the assumption that it is more expensive to build outside the urban centres. Consultations with trade sub-contractos were not conclusive either.

In extremely remote or isolated areas, not reviewed in this study, an adjustment to the budget would certainly be required.

The figures mentioned in the previous sections are meant to show the relative importance of various factors on the overall cost of school plants. These factors are to various degrees under the control of the School Boards and school designers, except for the influence of the location of the construction job site.

3.2 FACTORS AFFECTING THE BUDGETS (cont'd)

Other factors such as the advancement of technology in the construction industry, the development of new materials, the inflation and the upgrading of school plants due to new teaching requirements will be treated in the next section.

## 3.3 CONSTRUCTION COST TRENDS AND PERIODICAL BUDGET ADJUSTMENTS

The following factors are not under the control of School Board or school designers and have an effect on the overall cost which cannot be overlooked.

There are:

- Advancement of technology in the construction industry,
- Development of new materials,
- Inflation,
- Change in school plants due to new teaching requirements.

The first two factors mentioned above have a tendency of reducing the construction cost of building while the last two factors cause it to increase. It seems impossible at this time to evaluate even approximately the end results of these factors using a theoretical approach.

One method to adjust the budget for these changes could be to take the yearly average of actual construction cost and adjust the budget accordingly. This method has serious drawbacks in the

3.3 CONSTRUCTION COST TRENDS AND PERIODICAL BUDGET ADJUSTMENTS (cont'd)

sense that it does not take into consideration the quality and efficiency of the various designs and does not show the areas where improvement could be achieved.

Instead it is proposed that the actual cost for each school be adjusted either downward or upward to conform with the standards established as has been done in this Study. From these adjusted costs an average could then be made which could serve to re-adjust the budget yearly.

### 3.3.1 Detailed Estimate

In order to facilitate the Study mentioned in the previous paragraph, and for other reasons that we mention below, we recommend that for each construction project a detailed estimate be made from the final plans and specifications. This estimate should be similar to a contractor's estimate showing quantities and

3.3 CONSTRUCTION COST TRENDS AND PERIODICAL BUDGET ADJUSTMENTS (cont'd)

for each item. Such an estimate would have the following advantages:

- School Boards could better visualize how and where the money is spent on their schools,
- more precise comparisons could be made with other schools,
- meaningful statistics could be compiled which would yield valuable information to the Department of Education, the School Boards, architects and engineers,
- promotion of ever increasing efficiency of designs and cost control,
- promotion of closer cooperation between architects, engineers, builders and suppliers at the design stage,
- would allow corrections to plans and specifications before tendering if there are indications that the project would be too costly. As a result there would be general satisfaction that the price received is in fact the low price for the project in question.

3.3 CONSTRUCTION CCST TRENDS AND PERIODICAL BUDGET ADJUSTMENTS (cont'd)

3.3.2 Cost Information from Builders

In order to verify and correct the detailed estimate, it would be advisable to include, with the tender documents, forms requesting a breakdown of the tender price. The breakdown could, for instance, correspond with the items of the recommended budget as shown in Part III, Table 5. This could be requested as part of the bidding procedure.

# PART IV - SPACE AND COST PER STUDENT

So far, in this report, only the unit cost per gross square foot of floor area of school buildings was considered. It is generally a fair, practical and meaningful method of comparison of building costs. However, for school administrators and planners, the unit space and cost per student basis is vital information needed for future planning. This part of the report analyses this aspect of the case histories. In PartIV the costs per student exclude the costs of integrated equipment, site development and special conditions.

## 4.1 ELEMENTARY SCHOOLS

### 4.1.1 Space per Student

Graph 1 (page 135) shows the gross total recognized area per student for the schools studied. The recognized area varies somewhat for schools of the same capacity due to the fact that all schools do not have the same number of regular classrooms. These regular classrooms are replaced by other types of rooms which in some cases require more or less floor area.

Graph 1 (page 135) shows that as the schools get larger in terms of student, the space required per student decreases. The dotted line on this graph indicates the maximum recognized space per student under the present regulations.

Graph 2 (page 136) shows the actual, as built, space per student

for the schools studied. The deviation of the actually built areas from the recognized areas is more readily visualized in Graph 3 (page 137) which shows the percentage of deviation for each one of the schools. Seven (7) of the schools were built with less than the recognized area by 1% to 4%. Four (4) schools exceeded the recognized area by less than 1% and six (6) schools exceeded the recognized area by 3 to 15%. The major discrepancy for those last six schools can be attributed to the shelter rooms included in their design, and not recognized under the regulations pursuant to the School Buildings Act - Alberta Regulations 199/68. It should also be noted that in everyone of the elementary schools studied, the instructional areas actually built varied very little from the recognized areas.

### 4.1.2 Cost per Student

Graph 4 (page 138) shows the actual cost per student for the schools studied. There is a wide variation between schools of the same capacity. In some cases not only did the area per student exceed that of other schools of comparable size, but the unit construction cost was also higher. The cost result of those two components is shown on the graph.

Also shown on Graph 4 (page 138) is an "Upper Limit" line for a ratio = 65/35. This line comes from the multiplication of the maximum

4.1 ELEMENTARY SCHOOLS - Cost per Student (cont'd)

space per student (Graph 1) by the maximum budget recommended. Of the schools studied, seven (7) exceeded the "Upper Limit" by 4.5 to 30% and nine (9) were below by 1 to 14%. The "Upper Limit" curve indicates that the cost per student decreases with the increased capacity of the schools. The maximum cost for a 250 student school is shown as $1,400. while the maximum cost for a 550 student school is $1,210., a difference of 13.6%.

## 4.2 JUNIOR HIGH SCHOOLS

### 4.2.1 Space per Student

The recognized total area per student and the actually built area per student has been shown in relation to the capacity of the schools, on Graphs 5 and 6 respectively (pp 139 - 140). It should be noted that in the case of all the schools studied, the recognized total area has been based on a ratio of instructional to non-instructional area of 60/40. This ratio has since been changed to 65/35 thus reducing the recognized total space per student by 7.3%.

Graph 7 (page 141) shows both the deviation from the recognized area based on 60/40 ratio which governed at the time of design and also the deviation from the new ratio of 65/35. In the first case only one

school exceeded the recognized area and by less than 1%. All other schools were built with approximately 2 to 14% less space than recognized.

If we reduced the recognized area by 7.3% to conform to the new ratio of 65/35, then the majority of the schools would exceed the recognized area. It is to be expected, however, that if the new ratio of 65/35 had been in application at the time the schools were designed this would most likely have influenced their design and would have reduced the total actual area.

The dotted line on Graph 5 (page 139) shows the maximum recognized space per student based on the ratio 60/40. There is a very substantial decrease of maximum space required per student with the increased capacity of the schools. A 250 student junior high school requires a maximum of 185 square feet per student whereas a 700 student school requires 107 square feet or 43% less space.

### 4.2.2 Cost per Student

The actual cost per student was plotted against the capacity of the schools for the junior high schools as shown on Graph 8 (page 142). In this case the actual cost follows the theoretical trend shown by

4.2 JUNIOR HIGH SCHOOLS - Cost per Student (cont'd)

the "Upper Limit" curves.

The two curves shown on this graph represent the cost per student obtained by multiplying the maximum space per student (Graph 5) by the recommended budget for a ratio 60/40 in one case and in the other case for a ratio of 65/35.

Five of the schools exceeded the "Upper Limit" 65/35 by up to 24% while seven were below the same limit by up to 33%.

These curves show that the cost per student decreases sharply as the capacity of the schools increases. For instance using the "Upper Limit" 65/35 curve, we find that for a 250 student school the cost per student is $2,290.00, whereas the cost is $1,280.00 for a 700 student school for a difference of 44%.

## 4.3 SENIOR HIGH SCHOOLS

### 4.3.1 Space per Student

Graph 9 (page 143) shows the relationship between the space per student and the capacity of the schools in students for the actual areas built for the eight (8) schools studied. The trend for these eight (8) schools is the reverse of the trend observed for the elementary and junior high schools.

## 4.3 SENIOR HIGH SCHOOLS - Space per Student (cont'd)

Because of the small number of schools available, their difference in size and the fact that they included vocational shops, meaningful statistics on recognized areas could not be established.

### 4.3.2 Cost Per Student

Graph 10 (page 144) shows the relationship between the cost per student and the capacity of school in terms of students. As in the previous graph no definite trend can be detected.

## 4.4 GENERAL COMMENTS AND RECOMMENDATIONS

### 4.4.1 Elementary Schools

Graph 2 (page 136) showing the space per student in relationship with the capacity of the schools indicates that in this respect most elementary schools are within a fairly close range if allowances are made for the shelter rooms that some School Boards have added in some cases. Yet Graph 4 (page 138) shows a wide discrepancy between their cost per student. While the cost per student should be decreasing as indicated by the "Upper Limit" curve, the actual cost shows no such tendency. Some of the larger capacity schools are actually the costliest on a per student basis. Two schools of the same capacity have shown a difference in unit cost of as much as 50%.

4.4 GENERAL COMMENTS AND RECOMMENDATIONS - Elementary Schools (cont'd)

In the light of these facts, it is recommended that efforts be made to keep the total area of schools within the recognized area. Some of the extra cost in some cases can be attributed in part to the extra space built. These factors should be emphasized as a part of the efforts to keep costs below the budget figures outlined. In the case of elementary schools the high unit construction cost is the major factor which brought the per student cost above the "Upper Limit" curve. As a result the larger schools have proved more costly than the smaller ones, it should have been the reverse. Graph 4 (page 138) also indicates clearly that if schools were planned and designed to remain within the recognized area, and below the maximum budget, there would be savings in the initial cost of construction by building larger capacity schools.

Since the larger capacity schools included in the Study did not exceed 540 students, it is impossible to determine at this time where the advantages of increased capacity become negligible in terms of initial investments.

It is not the intention of this report to recommend any capacity of school because it is fully understood that the initial cost is only one factor in determining the desirable capacity. Other factors also influence

the economics of a school plant such as transportation, operation and administration costs. All those economic factors are also weighed against the pedagogical and sociological requirements which are of prime importance in the case of education.

It should be noted that the research team commissioned by the Human Resources Research Council in its report given in Appendix "B", mentions that school administrators are of the opinion that an elementary school of 500 students represents a desirable size and should also be a maximum.

4.4.2 Junior High Schools

Graph 5 (page 139) showing the recognized area per student in relation with the capacity of schools indicates a very sharp decrease of area required per student with the increased capacity. By examining Graph 7 (page 141) one realizes that the decision to change the ratio of instruction area to non-instruction area from 60/40 to 65/35 was sound.

It would seem advisable to be more specific in the allocation of space in the non-instructional areas.

The cost per student shows a very sharp decrease with the increased capacity of the schools much like the area per student as could be expected.

It was not possible to determine the capacity beyond which the decrease in cost becomes negligible since the largest school studied had a capacity of 720 students. The downward trend of the "Upper Limit" curve shown on Graph 8 (page 142) does not seem to end at schools of 700 students capacity and it would be advisable to investigate further this aspect. In view of the fact that during the coming years some classrooms will be empty alternately in elementary, junior and senior high schools due to a drop in the birth rate and because of the ever increasing use of high schools by the public for educational and recreational purposes, there might well be advantages, if pedagogically and administratively acceptable, to group in one building the junior and senior high schools. It would have the advantage of giving more flexibility in the use of classrooms and other instructional facilities avoiding, when enrolment drops temporarily at the various levels of education, unused facilities.

### 4.4.3 Senior High School

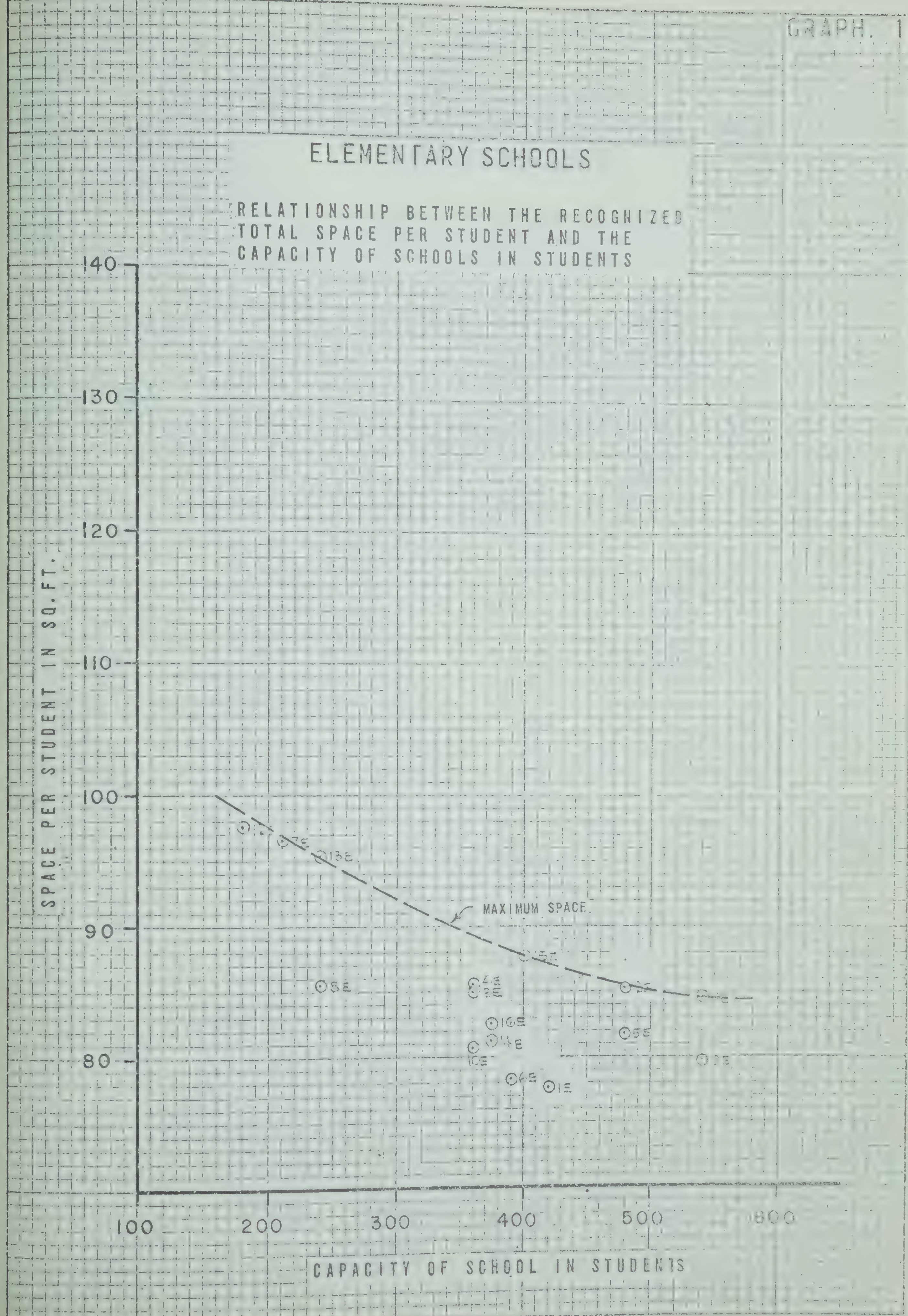
Graph 9 and 10 (pp 143-144) shows the space and the cost per student in relation with the capacity of the schools. The results are inconclusive. Efforts by the study group to establish areas and costs per student using theoretical schools have also produced inconclusive results.

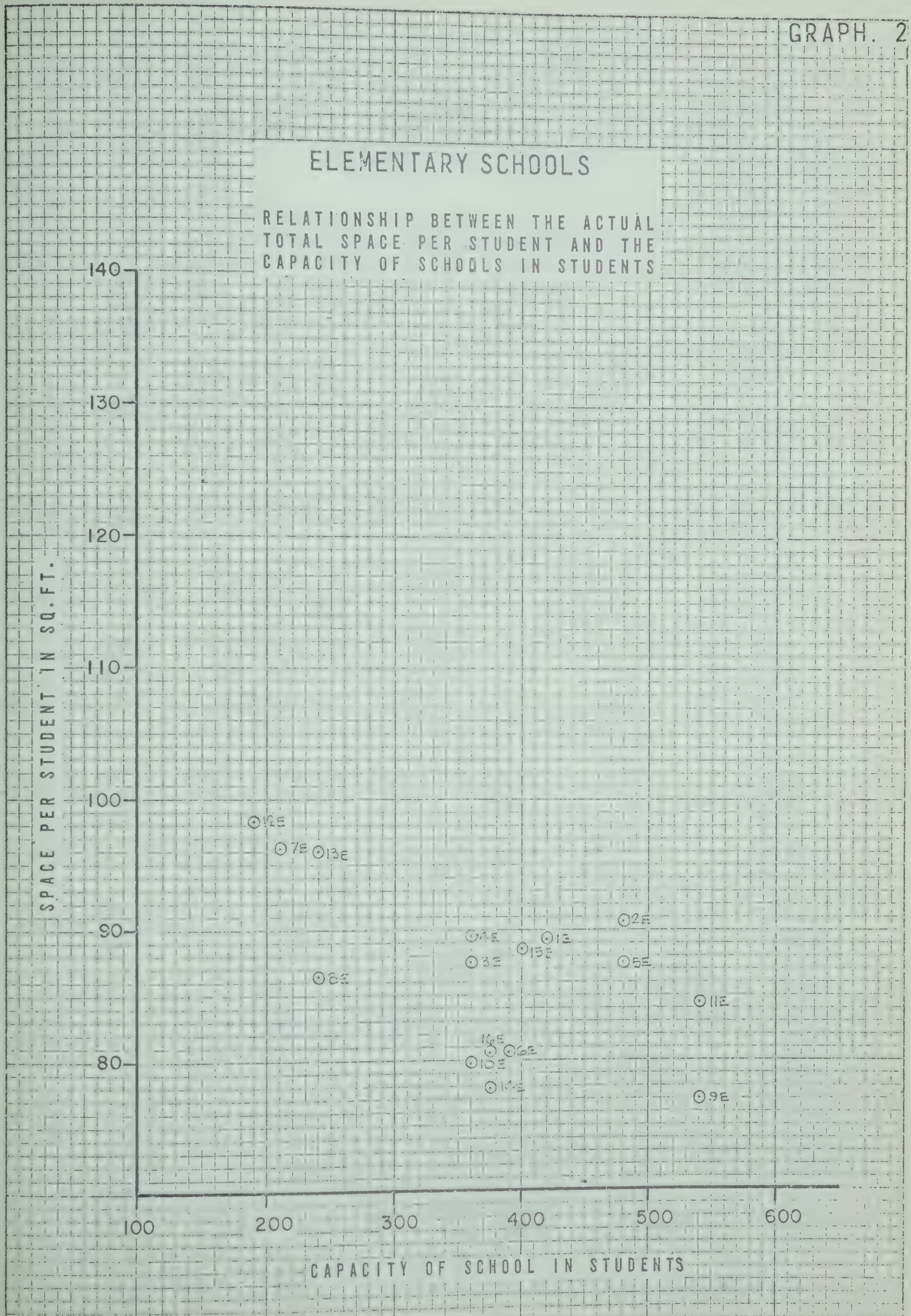
4.4 GENERAL COMMENTS AND RECOMMENDATIONS - Senior High Schools (cont'd)

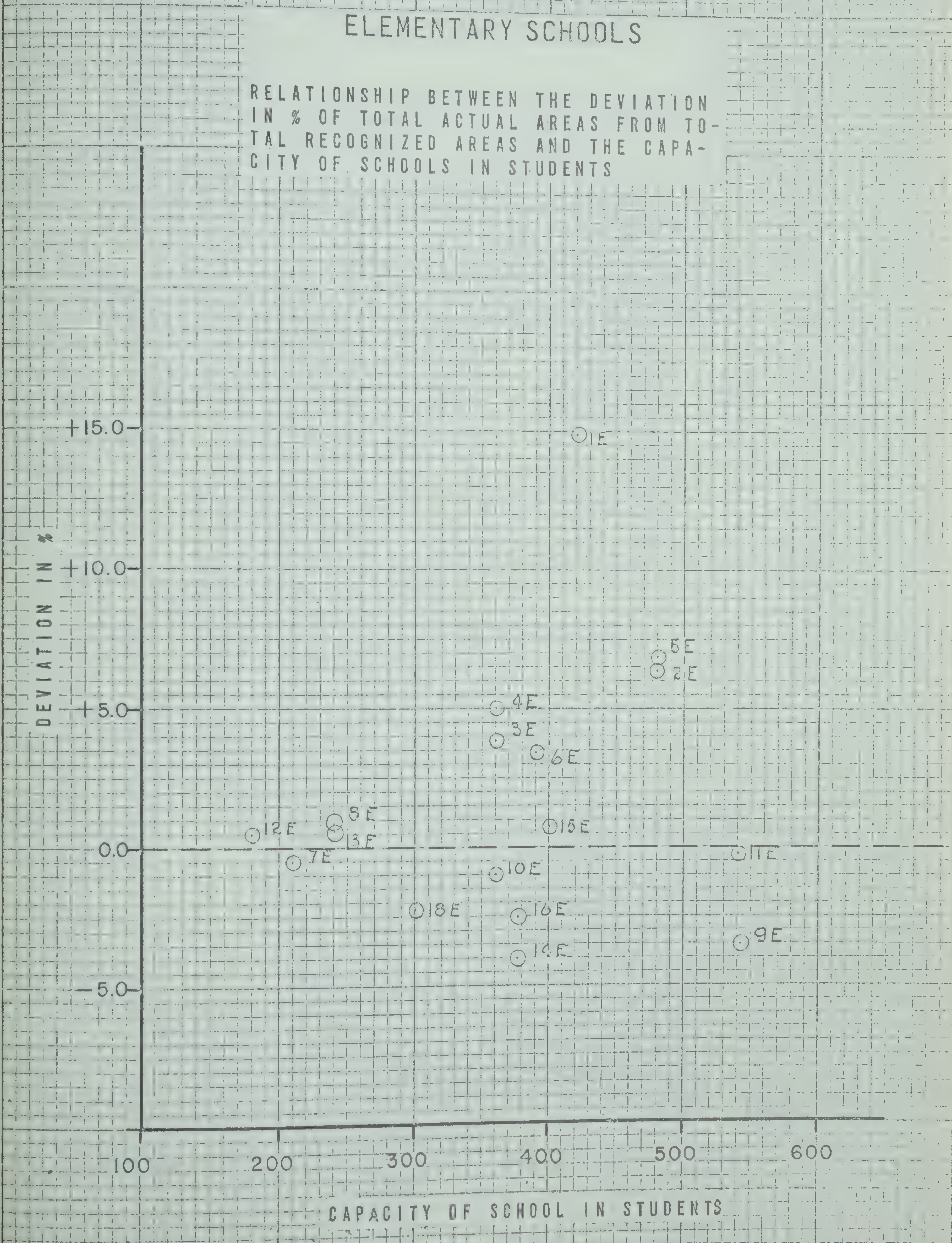
The use of a fixed ratio for instruction to non instruction areas becomes meaningless because of the services required by the various vocational shops and laboratories which vary greatly depending on the curriculum of these schools.

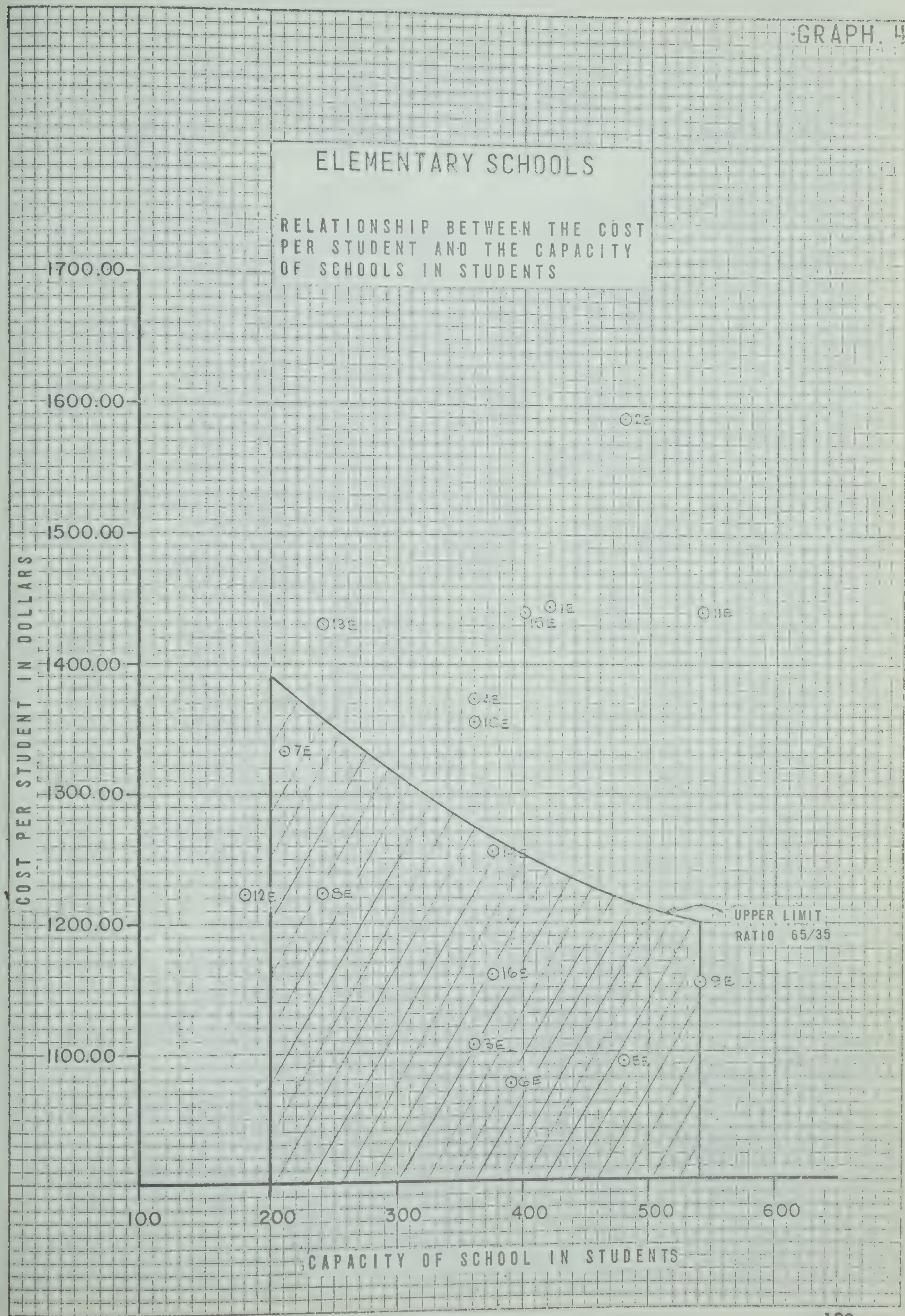
The graph showing the costs per student indicates that while for largest junior high schools the actual costs varied between \$1,200.00 and \$1,500.00 per student, the same unit costs at the senior level for larger schools varied from \$2,100.00 to \$2,750.00 per student.

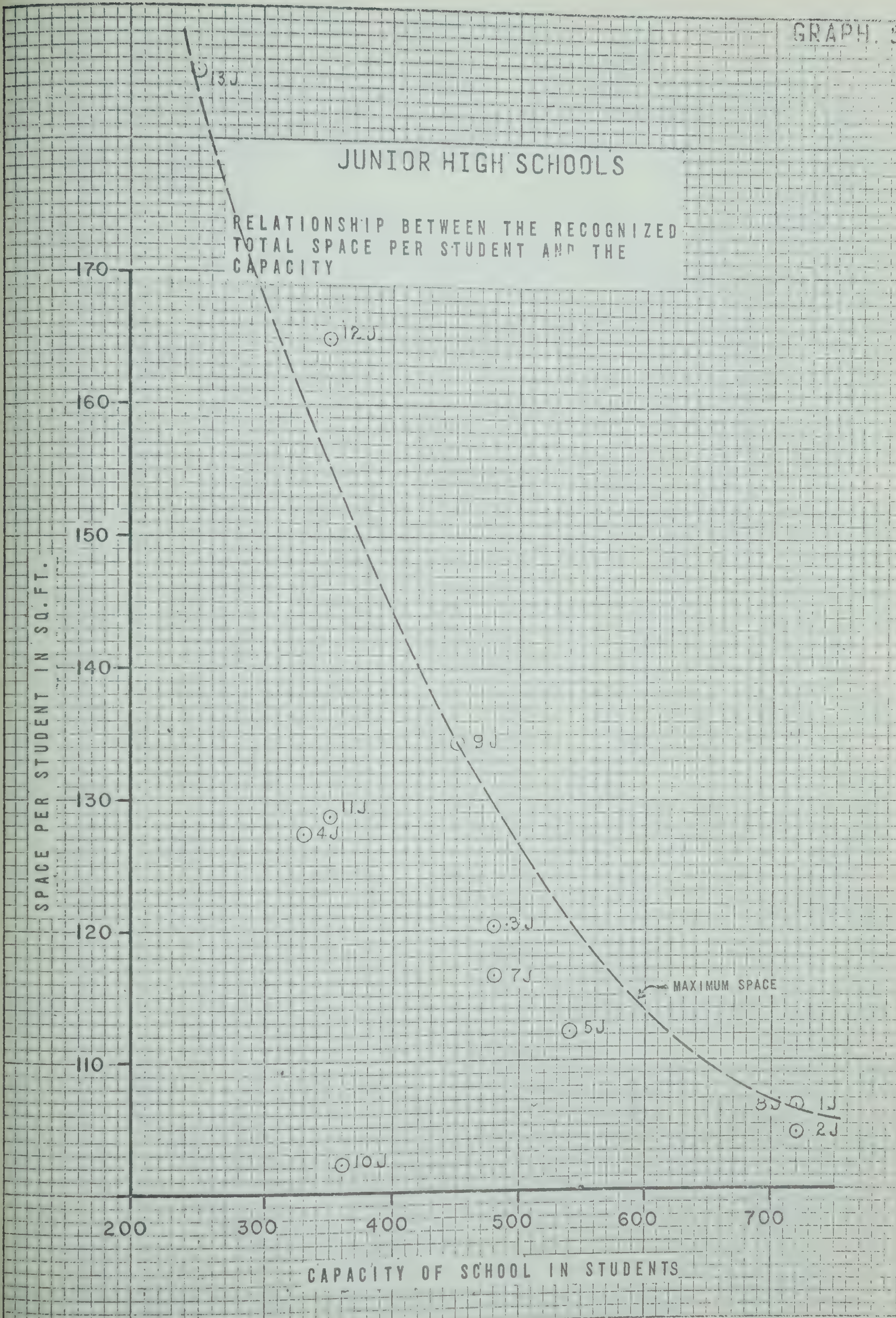
It is recommended that a further study be made of the requirements in facilities and spaces for each of the various subjects taught in senior high schools as it will, no doubt, be equally important to determine the type of equipment needed. It has been accepted that the facilities required at that level of teaching are much more complex and much more expensive than that at any other level of education, especially when translated on a per student basis.

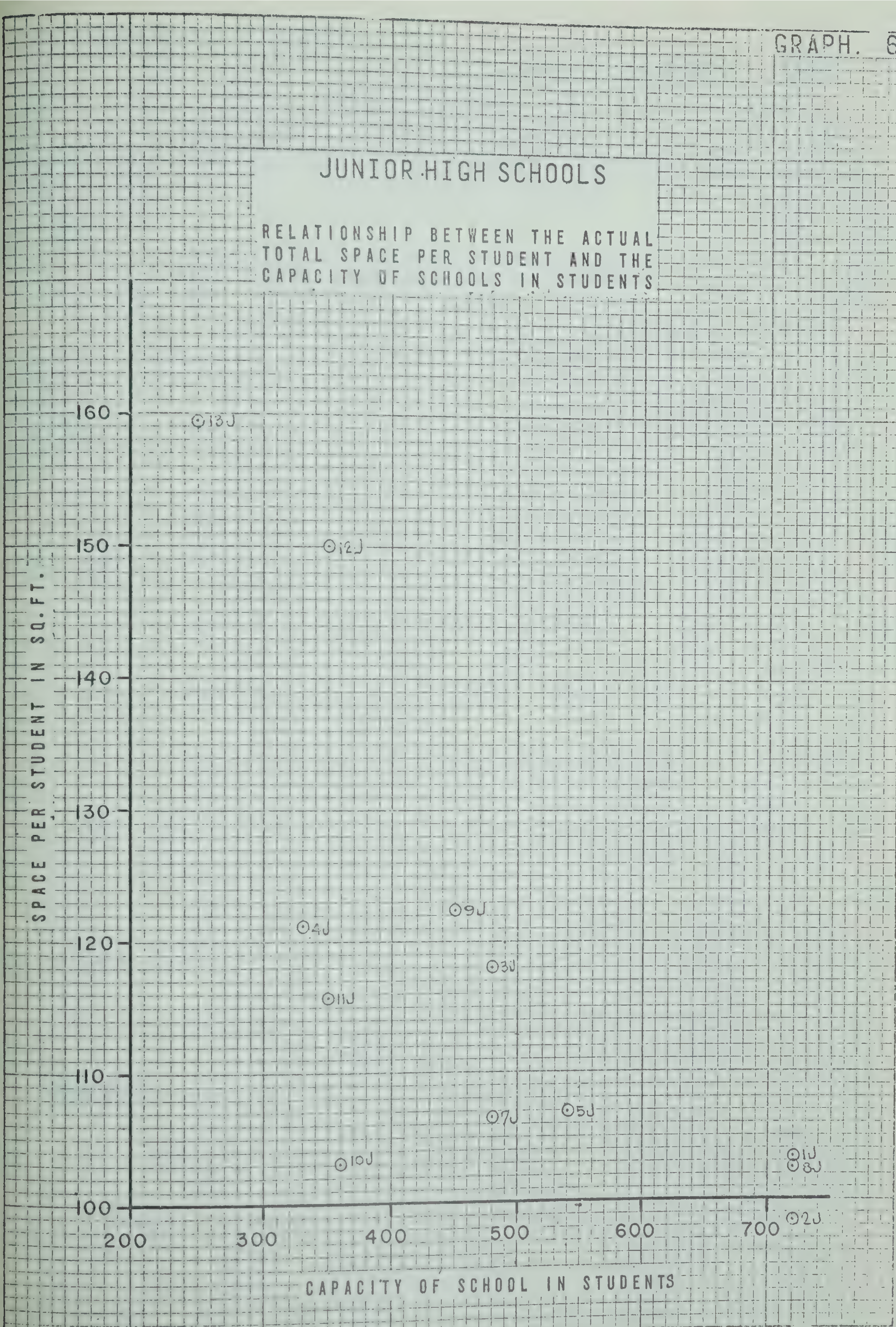

GRAPH. 1
ELEMENTARY SCHOOLS
RELATIONSHIP BETWEEN THE RECOGNIZED TOTAL SPACE PER STUDENT AND THE CAPACITY OF SCHOOLS IN STUDENTS
SPACE PER STUDENT IN SQ.FT.
140
130
120
110
100
90
80
100
200
300
400
500
600
CAPACITY OF SCHOOL IN STUDENTS
MAXIMUM SPACE
13E
8E
16E
4E
5E
6E
1E
10E


GRAPH. 2
ELEMENTARY SCHOOLS
RELATIONSHIP BETWEEN THE ACTUAL TOTAL SPACE PER STUDENT AND THE CAPACITY OF SCHOOLS IN STUDENTS
SPACE PER STUDENT IN SQ. FT.
140
130
120
110
100
90
80
12E
7E
13E
2E
4E
1E
15E
3E
5E
8E
11E
16E
6E
10E
14E
9E
100
200
300
400
500
600
CAPACITY OF SCHOOL IN STUDENTS

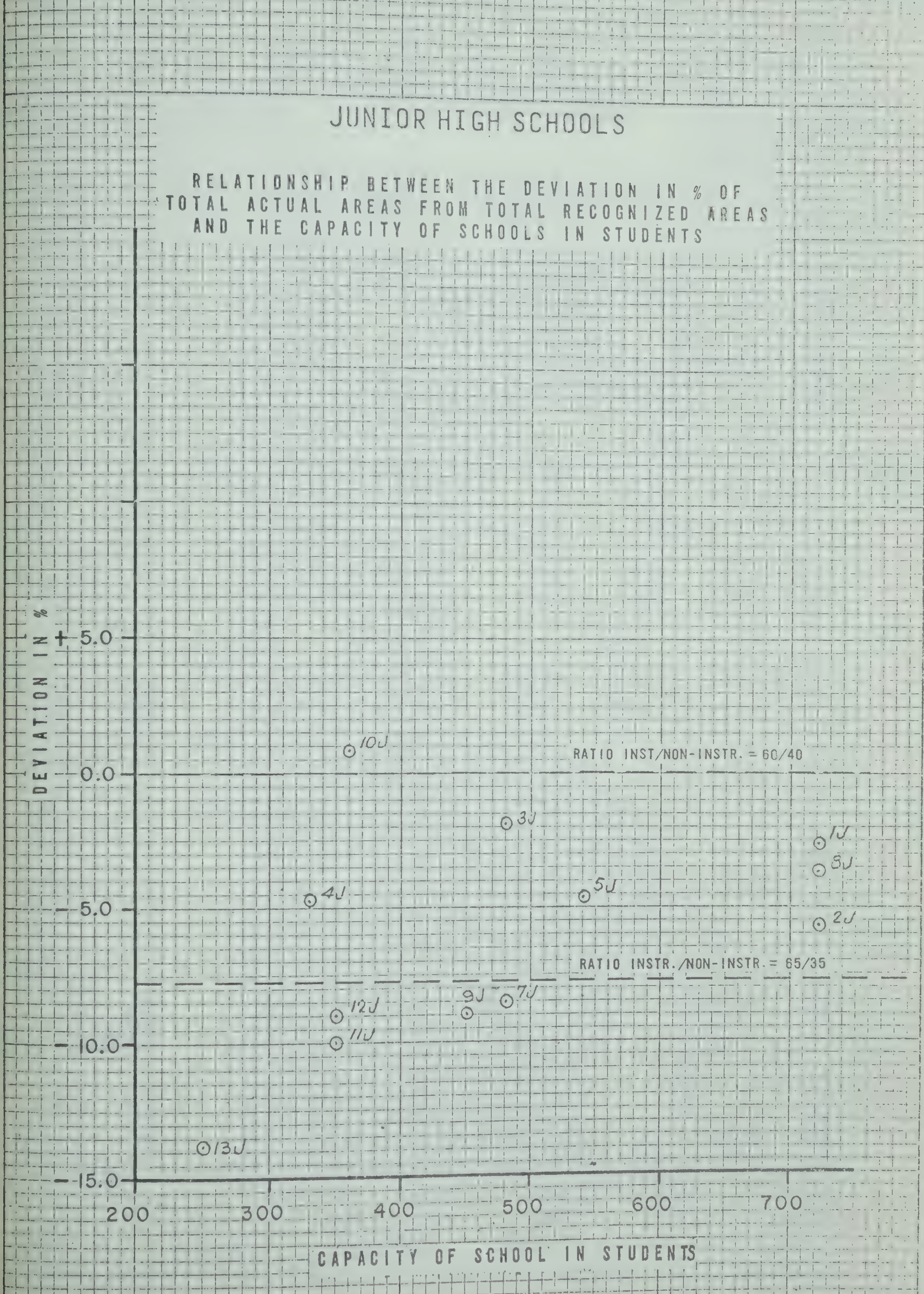

ELEMENTARY SCHOOLS
RELATIONSHIP BETWEEN THE DEVIATION IN % OF TOTAL ACTUAL AREAS FROM TOTAL RECOGNIZED AREAS AND THE CAPACITY OF SCHOOLS IN STUDENTS
DEVIATION IN %
+15.0
+10.0
+5.0
0.0
-5.0
1E
5E
2E
4E
3E
6E
8E
12E
13E
15E
7E
11E
10E
18E
16E
9E
14E
100
200
300
400
500
600
CAPACITY OF SCHOOL IN STUDENTS


GRAPH. 4
ELEMENTARY SCHOOLS
RELATIONSHIP BETWEEN THE COST PER STUDENT AND THE CAPACITY OF SCHOOLS IN STUDENTS
1700.00
1600.00
1500.00
1400.00
1300.00
1200.00
1100.00
COST PER STUDENT IN DOLLARS
100
200
300
400
500
600
CAPACITY OF SCHOOL IN STUDENTS
UPPER LIMIT
RATIO 65/35
2E
13E
1E
15E
11E
4E
10E
7E
12E
8E
16E
9E
3E
5E
6E


GRAPH. 5
JUNIOR HIGH SCHOOLS
RELATIONSHIP BETWEEN THE RECOGNIZED TOTAL SPACE PER STUDENT AND THE CAPACITY
SPACE PER STUDENT IN SQ. FT.
170
160
150
140
130
120
110
200
300
400
500
600
700
CAPACITY OF SCHOOL IN STUDENTS
MAXIMUM SPACE
13J
12J
9J
11J
4J
3J
7J
5J
8J
1J
2J
10J

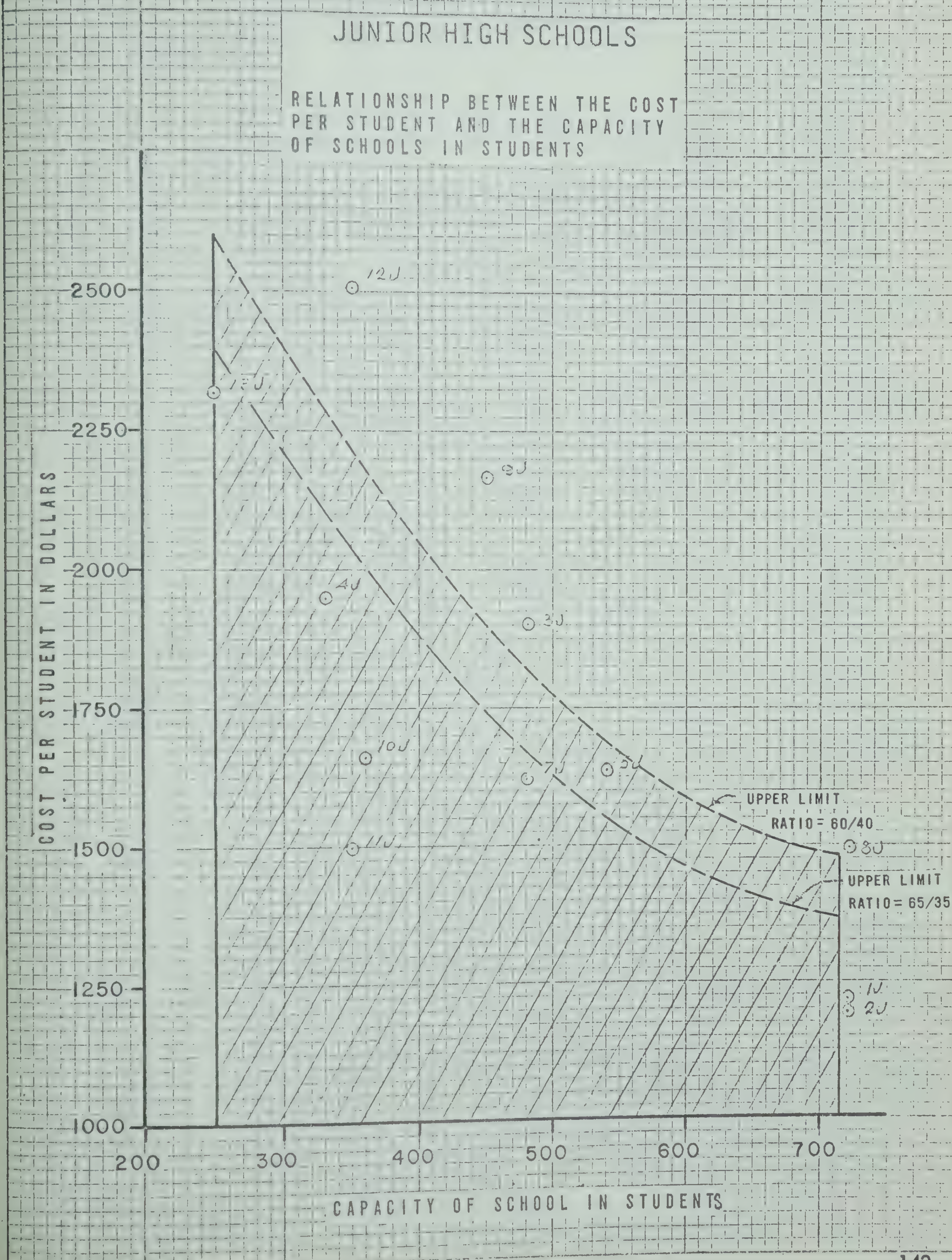

GRAPH. 6
JUNIOR HIGH SCHOOLS
RELATIONSHIP BETWEEN THE ACTUAL TOTAL SPACE PER STUDENT AND THE CAPACITY OF SCHOOLS IN STUDENTS
SPACE PER STUDENT IN SQ. FT.
160
150
140
130
120
110
100
13J
12J
9J
4J
3J
11J
7J
5J
10J
1J
8J
2J
200
300
400
500
600
700
CAPACITY OF SCHOOL IN STUDENTS

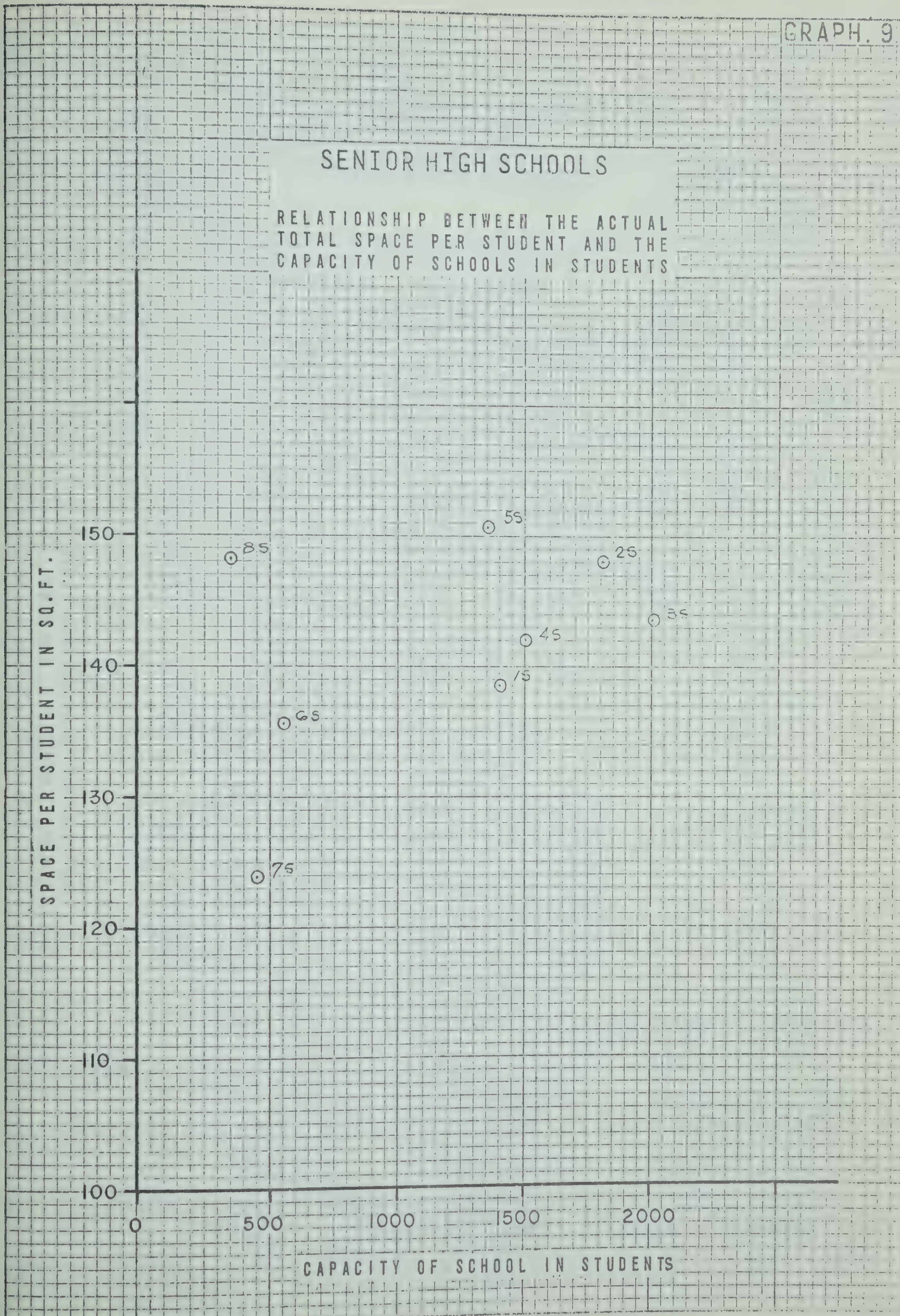
GRAPH. 7

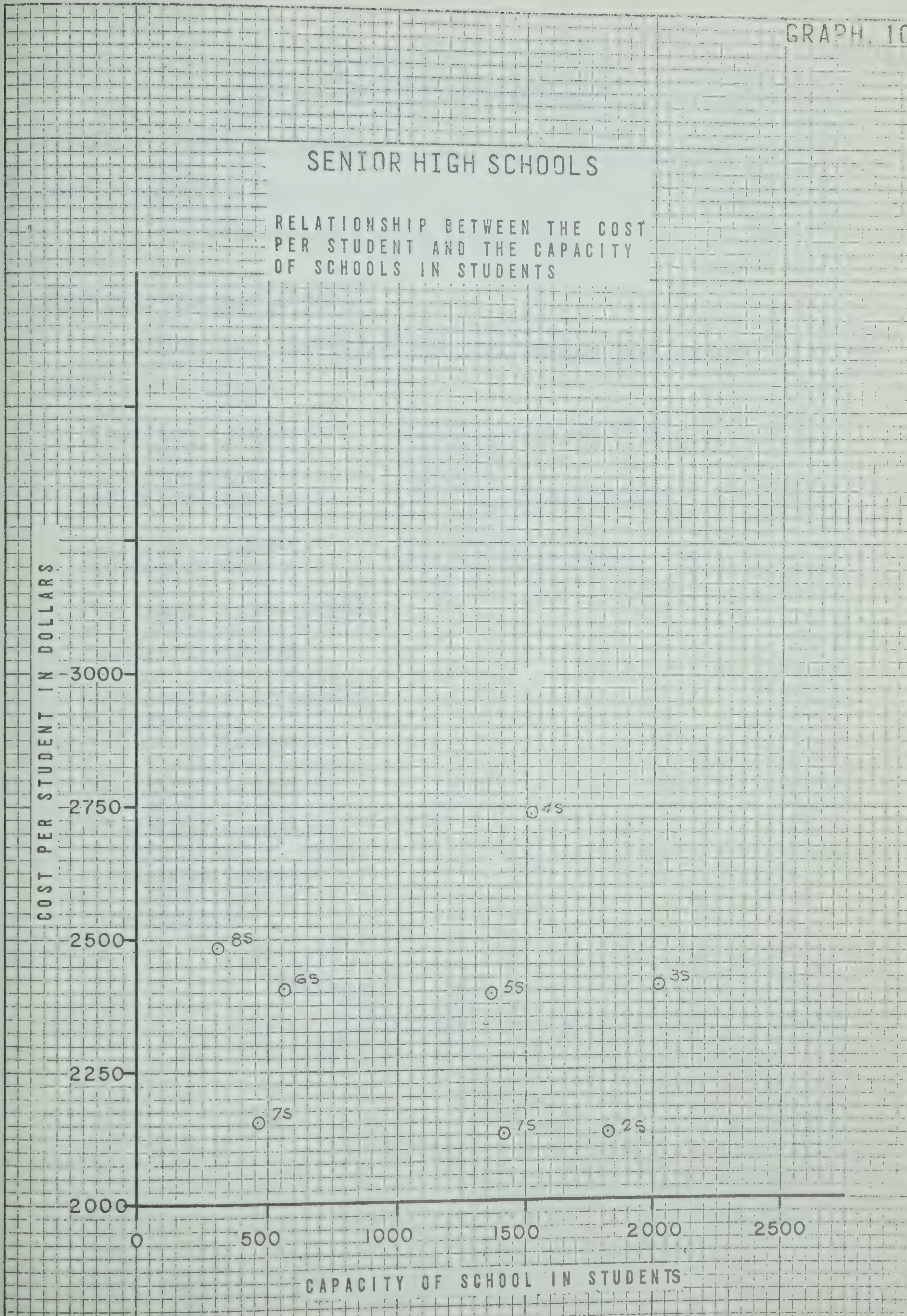


JUNIOR HIGH SCHOOLS
RELATIONSHIP BETWEEN THE DEVIATION IN % OF TOTAL ACTUAL AREAS FROM TOTAL RECOGNIZED AREAS AND THE CAPACITY OF SCHOOLS IN STUDENTS
DEVIATION IN %
+ 5.0
0.0
- 5.0
- 10.0
- 15.0
200
300
400
500
600
700
CAPACITY OF SCHOOL IN STUDENTS
RATIO INST/NON-INSTR. = 60/40
RATIO INSTR./NON-INSTR. = 65/35
10J
3J
1J
8J
5J
4J
2J
9J
7J
12J
11J
13J

GRAPH. 8


JUNIOR HIGH SCHOOLS
RELATIONSHIP BETWEEN THE COST PER STUDENT AND THE CAPACITY OF SCHOOLS IN STUDENTS
COST PER STUDENT IN DOLLARS
2500
2250
2000
1750
1500
1250
1000
200
300
400
500
600
700
CAPACITY OF SCHOOL IN STUDENTS
12J
4J
3J
10J
7J
11J
8J
UPPER LIMIT
RATIO = 60/40
UPPER LIMIT
RATIO = 65/35
1J
2J


GRAPH. 9
SENIOR HIGH SCHOOLS
RELATIONSHIP BETWEEN THE ACTUAL TOTAL SPACE PER STUDENT AND THE CAPACITY OF SCHOOLS IN STUDENTS
SPACE PER STUDENT IN SQ.FT.
150
140
130
120
110
100
0
500
1000
1500
2000
CAPACITY OF SCHOOL IN STUDENTS
8S
5S
2S
3S
4S
1S
6S
7S


GRAPH. 10
SENIOR HIGH SCHOOLS
RELATIONSHIP BETWEEN THE COST PER STUDENT AND THE CAPACITY OF SCHOOLS IN STUDENTS
COST PER STUDENT IN DOLLARS
3000
2750
2500
2250
2000
0
500
1000
1500
2000
2500
CAPACITY OF SCHOOL IN STUDENTS
4S
8S
6S
5S
3S
7S
7S
2S

## PART V - SUMMARY OF RECOMMENDATIONS

The order in which the following recommendations are presented is not necessarily the order in which they were given in the text, as the same subject is often discussed in the various sections of the report.

### 5.1 RECOMMENDED CONSTRUCTION BUDGET

The recommended construction budget for the various types of schools are as follows:

| | |
|---|---|
| Elementary Schools | \$15.05 per square foot of gross floor area |
| Junior High Schools Air Conditioned | \$15.25 per square foot of gross floor area |
| Senior High Schools Air Conditioned | \$15.10 per square foot of gross floor area |

The budget figures include:

-General Conditions

-Architectural Components

-Structural Components

-Mechanical Components

-Electrical Components

-Integrated Equipment

-Contingencies

5.1 RECOMMENDED CONSTRUCTION BUDGET (cont'd)

Does not include:

- Fees: architects and consultants
- Site development costs
- Cost of land
- Sales tax credits

To adjust the budget include architect's fees and deduct sales tax credits An additional 25¢ per sq. ft. should be added to the gross construction budget figures.

(Reference: Part III, Section 3.1)

5.2 PRELIMINARY PLANNING ESTIMATE

For each school construction project an itemized estimate adapted to the particular architectural concept for the various components of the projected building should be drawn up by the architects and their consultants and approved by the owners. (Reference Part III, Section 3.1)

5.3 PRE-TENDER ESTIMATE

A detailed estimate should be made from the final plans and specifications before tender call. This estimate should be broken down by specialities and be similar to a contractor's estimate showing quantities and unit prices.

(Reference: Part III, Section 3.3.1)

5.4 COST INFORMATION FROM BUILDERS

With the tender documents a form should be included which would indicate the cost information required from the builders. This information should

5.4 COST INFORMATION FROM BUILDERS (cont'd)

be submitted by the bidders with their tenders.

(Reference: Part III, Section 3.3.2)

5.5. YEARLY ADJUSTMENT OF BUDGET

Since some factors influencing the cost of school construction are outside the control of School Boards and school designers, it is recommended that the maximum budget be adjusted yearly to account for the effects of these factors. This could be done by adopting much the same method used in the research project. For each new school the various elements would be analysed and if necessary corrected to conform to the norm school. The average of these adjusted costs could be used for re-adjusting the budget if needed.

The detailed estimates and the information obtained from the builders would facilitate this operation greatly.

(Reference: Part III, Section 3.3)

5.6 CAPACITY OF ELEMENTARY SCHOOLS

Though the cost per student for elementary schools does not decrease as rapidly with the increased capacity as it is the case for junior high schools, it would still be advantageous costwise to keep the capacity of these schools as close to the size which is determined to be optimum from the pedagogical.

(Reference: Part IV, Section 4.1.2 and 4.4.1)

5.7 INTEGRATION IN THE SAME BUILDING-JUNIOR AND SENIOR HIGH SCHOOL

A number of junior and senior high schools appear to be similar in function. Some consideration should be given to the implications of combining these schools, to determine if the apparent saving due to a large plant is offset by other factors.

(Reference: Part IV, Section 4.4.2)

5.8 PLANNING COORDINATION

There would be much to be gained both from a cost point of view and performance of buildings by exercising a more efficient planning coordination control of school construction projects by the Department of Education.

5.9 AIR CONDITIONING

All new schools should be designed to include air conditioning both from the point of view of cost and comfort. The savings that such planning offers more than compensates for the extra cost of the cooling equipment and other extra equipment required.

(Reference: Part II, Section 2.3)

5.10 COMMUNICATION SYSTEMS

It would appear desirable for School Boards and the Province to give some considerable thought to the type of communication systems being installed in

5.10 COMMUNICATION SYSTEMS (Cont'd)

schools.

Considerable technological change is taking place in this area, and particularly in consideration of the trend to audio-visual aids compatibility of these systems throughout the Province will likely prove necessary.

Insofar as these developments are taking place at a rapid rate, close coordination with the agencies who will be responsible for transmission and utilization should be maintained so as to avoid installation of potentially redundant equipment.

(Reference: Part II, Section 2.4.5)

5.11 POWER TRANSFORMATION

Generally, primary switchgear and transformers should be supplied and installed by the Power Company since this increased capital expenditure when incorporated as part of the school cost, cannot be justified in relationship to the savings that accrue through purchasing power on a primary basis.

The location of the electrical room is important to facilitate this and should be considered during the early design stage.

(Reference: Part IV, Section 4.5.10)

5.12 RECOMMENDED STUDIES

Subject to review and updating, it was considered, in the technical

5.12 RECOMMENDED STUDIES (cont'd)

proposal presented originally by the Consultants, that the terms of reference of a further study would include the following subjects:

-Modular construction, flexibility and new techniques of construction.

-Use of standard products and bulk purchasing,

-Basic standards recommended for new school construction.

-Feasibility of renovating existing facilities to accommodate new teaching methods and programs (subject to budget permitting).

-The evaluation in terms of cost and planning of the detail findings from the continuing pedagogical study.

-Additions

-Upgrading

-Stagebuilding

Findings from this study pointed out specific items which should be studied in depth.

5.12.1 Architectural

-Space requirements for both instructional and non-instruction areas in elementary, junior and senior vocational high schools.

-Review and updating of the Alberta School Construction Handbook.

-Establishment of a method of analysis of plans and specifications and of the tabulation of information in order to yield the maximum valuable statistics.

-Assessment of the various materials commonly used in school construction.

5.12 RECOMMENDED STUDIES (cont'd)

for initial cost as against durability and maintenance.

-Analysis of acoustical problems.

-Analysis of the optimum economical sizes for schools.

### 5.12.2 Electrical

-Evaluation of the adequacy and profitability of the following systems against educational needs.

i) Sound Systems

ii) Clocks

iii) Active requirements for future ETV systems

iv) Stage Lighting

### 5.12.3 Mechanical

-Rooftop systems in regard to serviceability and life expectancy.

-Maintenance procedures for mechanical systems.

-Mechanical rooms space requirements.

-Profitability of some mechanical systems components.

APPENDIX "A"

ITEMS INCLUDED IN

CONSTRUCTION BUDGET

ITEMS INCLUDED IN THE DETAILED BUDGET

Each item of the detailed budget shall include the following:

1. General Conditions

   a) overhead

   b) profit

   c) contingencies

   d) site administration

   e) etc.

2. Roofing

   a) roof fill

   b) roof insulation

   c) vapor barrier

   d) membranes

   e) flashings

   f) skylights &

   g) etc.

3. Interior Walls and Interior Finishes

   a) concrete blocks and masonry

   b) plastering and drywall

   c) ceramic tile and terrazo

   d) ceiling finishes

e) floor finishes

f) painting and decorating

g) all carpentry

h) finish hardware and rough hardware

i) folding doors and mobile partitions

j) doors and frames

k) toilet partitions

l) etc.

4. Exterior Walls

a) windows

b) facing (brick, curtain walls, etc.)

c) insulation

d) concrete blocks or bricks

e) vapor barrier

f) lintels sills, stools

g) expansion joints

h) exterior doors

i) interior finish of exterior walls

j) fascias, eaves, soffits

K) etc.

5. Foundations

a) building excavation

b) backfill (20 feet from building)

c) formwork

d) concrete (including finishing and curing)

e) Rock base, sand fill and waterproofing membrance under slab

f) rough grading

g) normal piling

h) drain tiles

i) structural framing and concrete slab over crawl spaces

j) insulation and waterproofing of foundation walls

k) etc.

6. Superstructure

a) formwork

b) concrete (including finishing and curing)

c) reinforcing steel

d) structural precast concrete

e) concrete topping

f) structural steel

g) miscellaneous steel

h) glue laminated wood beams

i) structural framing lumber

j) wood sheating (structural diaphragm)

k) hybrid wood-steel trusses

l) etc.

7. Plumbing

a) storm and sanitary sewer systems

b) drains and pumps

c) hot and cold water piping

d) hot water tanks

e) pipe insulation

f) fire protection

g) gas systems

h) compressed air systems

i) plumbing fixtures

j) etc.

8. Heating

a) boilers and burners

b) oil tanks

c) piping, pumps, tanks and accessories in boiler room

d) smoke breeching

e) water treatment systems for boilers

f) controls

g) circulating pumps

h) heat exchangers

i) piping and heating units

j) insulation

k) etc.

9. <u>Ventilation</u>

a) air distribution system

b) fans

c) ducts

d) duct insulation

e) mixing boxes

f) diffusers

g) special ventilation equipment

h) air conditioning equipment if applicable

10. <u>Electrical</u>

a) service supply and transformation

b) lighting

c) distribution systems

d) emergency system and generator

e) fire alarm system

f) clocks and communication system

g) etc.

# APPENDIX "B"

# HUMAN RESOURCES RESEARCH COUNCIL

# REPORT

FACULTY OF EDUCATION / DEPARTMENT OF EDUCATIONAL ADMINISTRATION

October 30, 1969

Mr. Gilles Sebastien, P. Eng.
Project Manager
Reid, Crowther & Partners Limited
7410 Blackfoot Trail S. E.
Calgary, Alberta

Dear Mr. Sebastien:

The research team engaged by the Alberta Human Resources Research Council is primarily concerned with the contribution which school buildings and facilities can make towards the achievement of educational goals. In a very broad sense the overall goal of education in an industrialized society is the fullest development of all its human resources. This broad goal may be restated in terms of three major purposes of public education:

1. The provision of appropriate educational opportunities for all members of the school age group.
2. The provision of compensatory education for those members of the age group who are limited by personal, cultural, or social class characteristics.
3. Preparation for, and the opportunity to pursue, life-long learning activities.

In the attached chart (see Appendix A) these three major objectives are listed in column one under the heading "Pupils". In the same column the chart proceeds to list some of the related educational concepts and the current or emerging practices which are associated with these general objectives. The major implications of these practices for school buildings are then indicated in terms of the type of facilities required and the criteria which should be applied to them. The major criteria are adequacy, suitability, adaptability, and accessibility.

In the second column of the chart general objectives are stated as they relate to the professional staff followed, in turn, by related concepts and practices which give rise to certain facility requirements. The third column, following the same procedure, outlines the needs of the administrative group, and the fourth column, those of the community.

. . . ./2

This chart represents an initial attempt to establish a conceptual framework within which existing school facilities may be viewed and evaluated. As the research team proceeds with its study for the Human Resources Council it will continue to revise and refine this typology. However, for the purpose of assessing the particular list of schools with which your consultants are concerned, it has provided the basic frame of reference.

The research team visited some fifteen elementary, junior, and senior high schools located in Calgary and Edmonton. A tour of the school plant was made with the principal, or his assistant, and discussions were held with any staff members who were available. Emphasis was placed upon the functionality of the buildings in terms of the particular educational purposes and programs with which the staff members were concerned.

Schools at the high and low ends of the cost scale were paired for comparative purposes. An attempt was made to arrive at some subjective estimate of the significance of cost in terms of the functionality of the school plant. In general, it may be stated that cost did not appear to be the most significant factor. In some instances the more aesthetically pleasing buildings were somewhat higher in cost than those with lesser aesthetic appeal. In other instances, higher cost interior finishes were actually dysfunctional in terms of the needs of students and teachers. In some schools an improved quality of flooring appeared to add to the functionality of the building for elementary school purposes. In other instances, however, a less expensive type of flooring might have more adequately met the requirements of high traffic areas. Perhaps the most important single feature of the plant, in terms of its suitability for the educational program, was its general layout; the size and shape of the various space requirements, and the relationships among them.

In the general discussion which follows, elementary and secondary schools are treated separately. No attempt is made to identify particular schools or particular school systems.

## ELEMENTARY SCHOOLS

### School Size

There would seem to be some general agreement among school administrators that the maximum desirable size of an elementary school is in the neighborhood of 500 pupils. Usually the school principal feels that he would like to be able to identify most of the pupils in his school before they reach the sixth grade. An elementary school of the proposed size provides sufficient pupils at each grade level to allow for the organizational requirements of a continuous progress or non-graded approach to pupil

organization. At the same time it provides for sufficient staff resources to allow for some degree of specialization. An elementary school of some 500 enrolment justifies sufficient expenditures on library and audio-visual materials to provide adequate resources for the current elementary school program.

From the point of view of the educational program, the criteria for school size would include (1) adequacy in terms of organizational patterns, (2) adequacy in terms of efficient use of material resources, and (3) adequacy in terms of effective use of professional resources.

Aesthetic Features

Given that one of the educational objectives of the elementary school is to develop the aesthetic capacities of the students, some attention must be paid to the aesthetic qualities of the environment within which their learning takes place. What is considered as aesthetic from an architectural point of view, and what is aesthetic from the standpoint of an elementary pupil, however, may not be necessarily one and the same thing. For example, a textured concrete wall may be considered aesthetic by an architect, whereas a wall covered with the children's own creative work may be considered much more aesthetic from an educational point of view. Interior finishes which provide suitable backgrounds for well-planned displays of the children's work would appear to be more aesthetically desirable in elementary schools than textured concrete or brick and stone finishes which do not permit such displays.

The criteria for determining the aesthetic features of elementary schools should include (1) the quality of their appeal to children of elementary school age (2) the extent to which they contribute to a stimulating learning environment.

Entrance Halls

Entrance halls need to be inviting in appearance and sufficiently large to handle the traffic at peak periods. Their location in relation to street and playground facilities, and to major instructional areas within the school, need to be carefully considered. In several instances, entrance halls were found to be very inadequate in size, poorly located in relation to playground use, and with certain safety hazards in the outside staircases leading to them.

In terms of community use of school facilities the main entrance hall should be planned to give as direct access as possible to such areas as the gymnasium, the stage, the cafeteria and restroom facilities. For security reasons, it should be possible to close off the rest of the school from the areas leased to community groups. As community use of schools expands it may be desirable to think of having two or three class-

rooms adjacent to the community use area for the formal instruction of adult classes. In general, the schools visited have a satisfactory layout for current community purposes. However, being new schools, considerable expansion of community activities might be anticipated to occur in the near future. Most elementary schools did not have kitchen facilities which would be adequate for even limited community use.

Suitable criteria for entrance hall requirements would include (1) adequacy in terms of peak traffic requirements, (2) accessibility to administrative offices and community use facilities, and (3) suitability as a reception area.

Building Levels and Traffic Areas

From a functional point of view, split-levels would not appear to be desirable in the elementary schools. Such levels create problems not only in the flow of pupils but also in the movement of equipment from one part of the school to another. There would appear to be no serious disadvantages to a two-storey plan. A service elevator should be provided, however, for the movement of supplies and equipment and for occasional use by handicapped students or staff. If the major resource center is to be located on the lower floor of a two-storey structure, adequate access should be provided to it from the second storey, and, in addition, a supplementary reading or materials center might also prove useful on the second floor. It is likely that the primary grades would be located on the upper level and the senior elementary grades on the lower floor where they would have immediate access to the resources center.

There seems to be general agreement among the school personnel interviewed that the halls, or other traffic areas, are suitable and adequate for the schools' requirements. However, in elementary schools a more satisfactory solution needs to be found to the coats and rubber problem. The use of open areas does away with the traditional cloakrooms and no satisfactory alternative arrangement seems to have been found.

In planning elementary school buildings more attention might be given to the location of storage areas, particularly in relation to two-storey structures. This should take into account their accessibility from delivery entrances and from major instructional centers. In new buildings consideration might also be given to arrangements for the temporary addition of such mobile units as book mobiles, museums, etc.

The organizational pattern of the school and the location of the major resource centers, are the important considerations when buildings of more than one level are planned.

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Open Areas

The trend towards open area schools seems to be facilitating those educational practices which encourage independent study on the part of students and the full utilization of staff resources. Of the schools visited most open areas were either square or rectangular in shape. In view of the way in which classes are grouped for instruction, the question might be asked as to whether this is the most efficient and functional spacial pattern. In general, the areas were very attractive in appearance having relatively high ceilings, adequate lighting and satisfactory acoustical treatment. A good quality of cushioned carpeting is desirable, not only for its wear and acoustical qualities but also because elementary children very often carry out individual assignments or hold group discussions seated on the floor. Carpeting may not be necessary, however, in the adjacent high traffic areas.

Many open area classes use portable dividers in the form of either blackboards or "cupboards". It was found that teachers tend to remove these as they gain experience with the open area approach to instruction.

All open areas are planned with a central library resource center. The ready accessibility of the library to all instructional areas has resulted in a much greater use of its resources. It thereby contributes to individual and group learning activities and promotes improved instructional practices. Librarians generally feel the need for a work area of their own which is not too readily accessible to students. Such an area might be located on a raised platform in the center of the library. The platform would not only provide some degree of separation from the pupil-use areas but would also provide a vantage point for library supervision. In one of the schools visited a raised central area provided a pleasant and well-used space for quiet individual reading.

Closely associated with the library resource center are the audio-visual resources and the individual learning stations. The open area approach to instruction seems to greatly encourage the use of audio-visual aids. Convenient storage and viewing facilities for these aids need to be provided in the school plan. Electrical circuits have not always been planned to meet the increased audio-visual requirements.

The nature and use of individual study carrels varies from school to school and seems to be dependent to some extent on the resources available as well as the interests of the staff. There were positive indications, however, that individual study carrels have a great potential in relation to independent learning in the elementary school. They need to be strategically located between the open classroom areas and the library resource center, thus enabling them to be supervised by the class teachers or by the librarian.

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Classroom Space

Although the open area plan has gained considerable support from the teaching staff in the schools visited, there seems to be general agreement that the need existed for what one system called back-up rooms. In some cases, such rooms are regular classrooms in design, others have special features. Back-up rooms serve many purposes among which are the following (1) seminar areas for group discussions, (2) project rooms where materials may be spread out and left from one period to the next, (3) art rooms having special plumbing and storage facilities and large work areas, (4) science rooms with laboratory tables, storage for laboratory materials, and display areas, and (5) viewing rooms for sound films which might disturb classes in the open areas.

It is a question as to whether these back-up rooms need to be entirely separated from the large open areas or whether they could be planned as extensions off them. There is also the question as to whether they should be large enough to accommodate a whole class at one time or only a smaller group. The answers to these questions would depend upon their particular use, therefore the installation of folding doors might provide the necessary flexibility.

The type of wall treatment in classroom areas is important in the elementary schools. Teachers at this level cannot have too much display area, therefore rough or hard finishes are unsuitable for their purposes. In a number of the standard-type classrooms which were visited the teachers indicated that the shelving and storage facilities were entirely inadequate. (In planning such details teacher participation would be most valuable.) Complaints were also registered at the limited blackboard space available. Although considerable use is being made of overhead projectors, teachers like to have sufficient blackboard space for their instructional needs. In the primary grades they should be suitably placed to enable students to work at them. If classrooms are to be used for science activities, suitable plumbing facilities need to be provided and an outdoor light source is required for plant science activities.

Music Rooms

At the elementary level, it is doubtful whether the music program requires the elaborate music room facilities found in junior and senior high schools. Many elementary schools, however, have special fine arts rooms which are particularly suited to music classes. The most successful of these are carpeted areas planned on several levels either in a square or U shape. The levels provide risers for formal choral or instrumental work, seating for other forms of instruction, and

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multi-level staging for creative activities. In addition, the carpeting adds to the acoustic qualities of the room. Although chairs are not required, some storage facilities are necessary for song books, sheet music, records, tapes, instruments, and audio-visual equipment.

If one side of such a room were to adjoin the auditorium stage rehearsals would be greatly facilitated and the room could serve as a change room during school programs.

Gymnasium

For the average elementary school of fifteen to eighteen rooms, a gymnasium square in shape, permitting two volleyball courts across the width of the room, would allow for maximum utilization of space. A narrower gymnasium limits its effectiveness for inter-mural games and class activities. The provision of a larger gymnasium with an operable wall dividing it into two separate gyms seems to create acoustic problems. The need for change and shower facilities in elementary schools is a question which instructors in physical education are now raising.

It has been common practice to use the gymnasium in an elementary school as its auditorium. In general, this has proved satisfactory though the acoustic problem has not always been adequately solved. In order to avoid the necessity of setting up chairs it is customary to have pupils seated on the gymnasium floor during school assemblies. With this in mind, the stage level should be designed at a suitable height. The provision of a fore-stage in front of the proscenium arch, with permanent carpeted risers leading up to it, might meet the stage requirements for many informal, and some formal occasions. The risers and the fore-stage would be suitable for massing school choirs, or small instrumental ensembles. This arrangement would prevent the loss of volume from young voices which often occurs when groups are massed behind the proscenium arch. The risers would provide ready access to the stage and at the same time could serve as viewing stands for gymnasium activities.

As presently designed, stages in elementary schools are generally under-utilized and not as functional as they might be. If folding doors, having good acoustic qualities, could separate the stage from the auditorium the space could be utilized for some instructional and project purposes. If, as suggested earlier, one side of the stage could be opened into the music room or into a fine arts room, greater utilization of the stage area might be ensured.

If classes of students are to be moved on and off the stage during performances, it is important that two exits be provided in order to expedite the flow of traffic and ensure safety. One exit might lead to a fine arts or project room and the other into a hall with conveniently located washrooms.

Administrative Areas

The administrative areas seem to be adequately provided with offices for staff and conference purposes. In several schools, however, the need was felt for a general work area for the clerical staff. Space adjacent to the general office is required for duplicating facilities and for the assembly of materials to be distributed to instructors.

The trend toward team teaching, which is being encouraged by open area plans, is necessitating the provision of adequate planning space for the teaching teams. Perhaps several smaller planning areas, accommodating three or four teachers, would be preferable to the provision of one large work room. These areas should be adjacent to that section of the open area in which the teachers are working. The school's library resource center should also be readily accessible to these planning centers. It seems undesirable to have teacher work areas as open extensions to staff rooms. The different purposes of each may prevent the adequate functioning of either. A work space separated from the staff room by a folding wall would enable either the work room or the staff room to be extended for special occasions.

In order that the administrative staff may work with teachers in their planning activities, a staff conference room is required. For convenience this should be adjacent to the administrative offices where pupil files are readily accessible. In addition to its use for staff planning such conference areas would be available for meetings with parent or community groups. A small room for counselling or testing purposes and for parent-teacher interviews might also be provided.

SECONDARY SCHOOLS

An analysis of the component features of "expensive" and "economy" schools does not lend itself very readily to generalizations which could be translated into degrees of adequacy. For that purpose, some sort of scaling procedure is required. However, as a general proposition, it can be stated that the selected high schools are characterized by a fair amount of conservatism, and the traditional core areas in curriculum appeared to reflect this conservatism. Some of the emerging trends in pupil organization and instruction were not as apparent in secondary schools as in the elementary.

It is suggested that in the general planning procedure, perhaps more emphasis might be placed on social and psychological aspects with some toning down of the academic dimension. For example, architectural arrangements which promote and foster esprit, loyalty, and strengthened

social relationships might be encouraged. At the secondary level of schooling aesthetic considerations have a considerable role to play. The aesthetic treatment of the school, both on the interior and the exterior, can add considerably to its attractiveness as a learning environment. The use of color in halls and locker rooms in some of the schools visited indicates the potential of this inexpensive form of aesthetic treatment.

As a general proposition there is a need for (1) spacial variety, to accommodate growing trends toward independent study, differential rates of progress, etc. (2) flexibility, inasmuch as it relates to the convertibility of designated spaces in day-to-day operations as well as in its long-range aspects, plus the provision for expansion (3) variety in the general structure. There is a persisting limitation in the general preference for the rectangular classroom. The only variation in some cases is a change from a teaching station along the short wall to one on the long wall. Wedge-shaped rooms appear to be quite promising in improving sight-lines and making increased flexibility possible by combining one area with another for large-group instruction.

Spacial Pattern

The philosophy of comprehensive secondary education implies broad programs and large enrolments to justify them. As pupil enrolments rise to the two thousand figure two major problems develop: those of identity and integration. There is the ever-present danger in large schools that individual pupils and teachers, and even classes and departments may lose their identity. At the same time there is the problem of integrating the varied activities, courses and programs in such a way as to produce a unified whole which can be called a secondary school. School design can help to alleviate these problems if spacial planning takes them into consideration.

Social Science Cluster

While some authorities suggest that classrooms and laboratories should be clustered according to subject, others contend that this promotes duplication of services and creates insular groups of staff and students. To promote a better mix perhaps it is in order to pivot the classroom arrangement around the service requirements.

In the schools visited the library was found to be the center of the major cluster which included social studies and English class-rooms. In the more effective situations the library resembled the resource center in the open area elementary schools by having sliding glass partitions which opened up its resources to the classrooms around it.

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The core of the library is an office and work area for the librarian. In one of the more desirable plans provisions had also been made for the storage and servicing of audio-visual equipment. Individual study carrels will form an increasing part of the library center as instructional practices encouraging independent study are extended. In planning the library as the central focus of the social science complex the cluster of rooms associated with it should include conference areas for small group discussions and the preparation of group reports. Such conference areas could also be used for audio-visual purposes, either by groups or individuals.

Physical Science Cluster

It is conceivable that other cluster arrangements around service centers might be planned for secondary schools. No schools visited, for example, had a physical science cluster. Yet this practice is not uncommon in American schools. The heart of such a cluster could be an independent research center which would contain appropriate laboratory and library facilities. Associated with it could be a materials storage center and a planning and work room for the instructional staff.

The present practice of including laboratory tables in classrooms limits their use for independent study purposes to unscheduled periods. In some schools visited, storage and preparation areas were inconveniently located in relation to the students' laboratory facilities.

Other cluster areas could be planned in the fields of mathematics and foreign languages where the central resource center for the cluster would combine specialized library facilities with carrels for student use and a conference and planning area for staff. The design should include ready access to the resource center from the instructional area. Glass panels might simplify supervisory problems.

Fine Arts Cluster

The fine arts cluster, in a large secondary school, would be focused around the auditorium facilities. In addition to its use for fine arts classes, however, the auditorium may often be used for large group instructional purposes, and school assemblies. It is also an area which might receive considerable community use. The more effective secondary school plans enable the stage to be used as an extension of the music room and also locates it adjacent to an art or project room. Very fine music room facilities were found in all of the schools visited. If the schools were to go on modular scheduling and to encourage independent study more practice room facilities might be desirable where instrumental programs are being developed.

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For drama classes, a supplementary stage which could be an extension of the auditorium stage, has proved useful for instructional purposes. An operable acoustical wall between the stage and the auditorium would make it more readily accessible for rehearsals and instructional purposes to all fine arts departments. The halls around the fine arts cluster could be designed as galleries for art displays.

Vocational Cluster

Well-equipped shops were found in all of the secondary schools. Perhaps a bridge between the vocational and academic areas might be established by creating a technical resource center which would have an appeal to students in both academic and vocational programs. It is possible that vocational counselling services could be associated with this center.

Administrative Area

Adequate provision seems to have been made for the administrative requirements of the large secondary schools. In designing the spacial arrangements of these facilities it seems desirable to have an access to the counselling area, which is separate from that to the administrative area. The two, however, need to be back to back in order that the files will be available to both services.

Perhaps too little attention is being paid in secondary school planning to student needs for suitable places to carry on informal study and discussion activities. The cafeteria is often made available for this purpose when not in use for lunch purposes. However, the formal seating plan in most cafeterias would have to be modified in order to meet the requirements of informal student activities. A school designed on a cluster plan could include some informal meeting area as a component of each cluster, thus helping to bring together students with common interests.

Facilities for the receiving of equipment and supplies have been adequately planned in most of the large schools. An unloading bay with a screened receiving area adjacent to it enables supplies to be temporarily stored until they can be directed to a more permanent location. A service elevator would need to be located near the receiving center.

CONCLUSION

The preceding comments summarize the major findings of The University of Calgary research team based on its investigation of the schools designated by the Department of Education. The suggestions which have

been included will be checked out and refined further as our team's own research project goes forward. We trust, however, that some of the comments will prove useful to you and to the Department in arriving at your own conclusions.

The sketches in Appendix B and C suggest some of the spacial arrangements which might meet the criteria of flexibility and accessibility.

Sincerely yours,

J. E. Cheal

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cc Mr. J. Hudson
A.H.R.R.C.

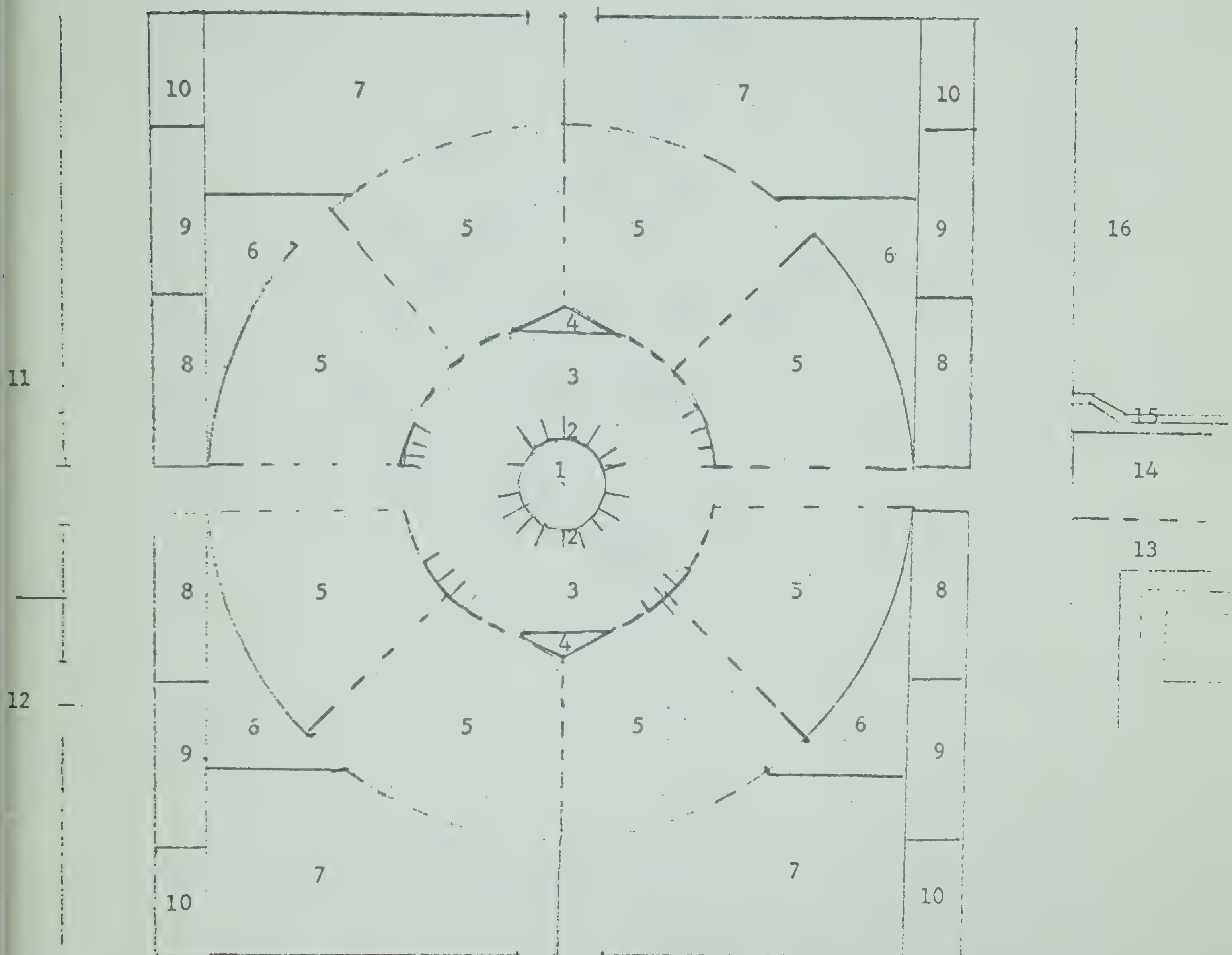
Dr. L. Hall
Department of Education

APPENDIX A

| | PUPILS | STAFF | ADMINISTRATION | COMMUNITY |
|---|---|---|---|---|
| GENERAL OBJECTIVES | i. Appropriate opportunities for 5-19 age group<br>ii. Compensation for cultural, social class, individual limitations<br>iii. Preparation and opportunity for life-long learning | i. Full utilization of staff resources<br>ii. Staff particpation in program development<br>iii. Continuing professional development opportunities | i. Development and supervision of the instructional program<br>ii. Concern for pupil progress and welfare<br>iii. Efficient utilization of all resources<br>iv. Effective communication | i. Two-way communication with the school<br>ii. Maximum utilization of building facilities<br>iii. Support of community activities<br>iv. Solution of community problems |
| RELATED CONCEPTS | i. Wide range of individual differences<br>ii. Socio-economic factors as determiners of need, ability<br>iii. Learning through independent inquiry<br>iv. Social need satisfaction important | i. Increased specialization<br>ii. Cooperative planning and instruction<br>iii. Increased professionalization<br>iv. Increased use of technologies | i. Instructional leadership<br>ii. Shared decision-making<br>iii. Human Relations emphasis<br>iv. Systems approaches<br>v. Public relations emphasis<br>vi. Providing support services | i. Shared resources<br>ii. Cooperative planning<br>iii. Year-round and extended-day use of facilities<br>iv. Communication of needs and efforts |
| RELATED PRACTICES | i. Variable grouping<br>ii. Continuous progress patterns<br>iii. Flexible scheduling<br>iv. Inquiry methods & Laboratory<br>v. Independent study<br>vi. Alternative course patterns<br>vii. Participation in decisions | i. Team teaching<br>ii. Planning and preparation periods<br>iii. Use of non-professional aides<br>iv. Use of educational technologies | i. Leadership in program development<br>ii. Supervision of the instructional program<br>iii. Pupil & parent counselling<br>iv. Scheduling and organizing<br>v. Reporting & Budgetting | i. Recreational programs<br>ii. Adult evening classes<br>iii. Home & school activities<br>iv. Welfare services<br>v. Summer schools & Playground activities |
| FACILITY REQUIREMENTS | i. Regular classrooms<br>ii. Large group instruction areas<br>iii. Small group discussion areas<br>iv. Facilities for independent study (library & laboratory)<br>v. Facilities for group projects<br>vi. Resource centers-(library, gym)<br>vii. Entrance & circulation areas<br>viii. Washroom, coat facilities | i. Team planning areas<br>ii. Materials & work areas<br>iii. Counselling rooms<br>iv. Storage facilities<br>v. Staff lounge | i. General office & work area<br>ii. Administrators' offices<br>iii. Conference areas<br>iv. Counselling area<br>v. Storage facilities | i. Gymnasium<br>ii. Stage & auditorim<br>iii. Classrooms<br>iv. Storage facilities<br>v. Washroom facilities<br>vi. Conference rooms<br>vii. Cafeteria facilities |
| FACILITY CRITERIA | i. Accessibility of heavy use areas<br>ii. Adequacy of space<br>iii. Adaptability of spacial arrangements<br>iv. Adequacy of lighting, acoustics<br>v. Aesthetic appeal | i. Accessibility of areas<br>ii. Adequacy of facilities<br>iii. Suitability of facilities<br>iv. Aesthetic appeal | i. Accessibility of areas<br>ii. Adequacy of space<br>iii. Suitability of facilities | i. Accessibility of joint-use facilities<br>ii. Adequacy of space<br>iii. Suitability of facilities |

APPENDIX

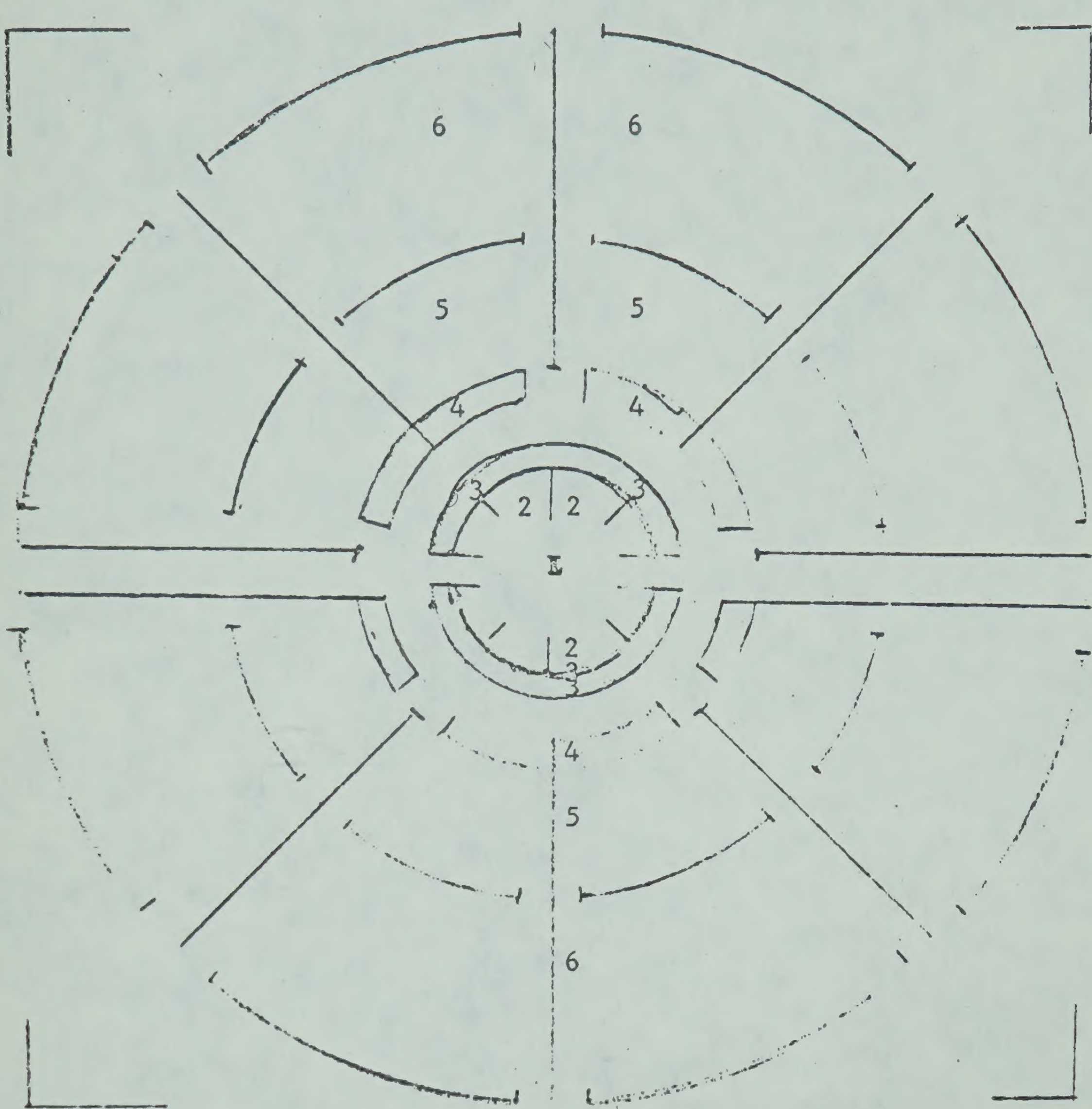
ELEMENTARY SCHOOL OPEN AREA RELATIONSHIPS




1. Librarian's work area
2. Individual study carrels
3. Library resource center
4. AV resources
5. Class areas
6. Teacher planning areas
7. Back-up classrooms
8. Washrooms
9. Cloakrooms
10. Storage
11. Administrative Area
12. Health services
13. Music room
14. Stage
15. Auditorium

APPENDIX C

PHYSICAL SCIENCE CLUSTER




1. Teachers' planning area
2. Teachers' carrels
3. Materials storage and preparation area
4. Independent project lab tables
5. Laboratories
6. Classrooms